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EDITORIAL

THE INSECT INFESTATION OF CACAO BEANS

THE infestation by insects of cacao beans while in store at certain wharves and docks in London has been regarded as a problem of importance for many years. Although several insects are concerned, the most important are moths of the genus *Ephestia*. Apart from the actual loss of the stored product directly due to insect attack, the transference of infested beans from the warehouses to chocolate factories leads to the liberation of moths in the latter buildings with the resultant danger of infestation of manufactured chocolates and cocoa. Furthermore, as *Ephestia* moths do not confine their attacks to cacao, the presence of stocks of infested cacao beans in warehouses in which are stored certain other products liable to attack by the same insects constitutes a source of contamination of these products which causes those concerned a good deal of anxiety.

The problem is a three-fold one—infestation in the exporting country, in the London warehouses and in the cocoa and chocolate factories in various parts of England. The solution of the second and third aspects of this problem would present no serious difficulty if the first did not arise, and it was for this reason that an investigation was decided upon by the trades concerned with the primary object of determining the precise source of infestation in exporting countries. The principal countries exporting cacao to England were invited to collaborate in this inquiry and the results of Ceylon's participation in the investigation are given in this number of our journal.

Of the 34,000 acres under cacao in Ceylon, approximately 70 per cent. are controlled by small-holders, the balance consisting of large European-owned estates and a few small estates owned by Indian Tamils. The course followed by the cured cacao of these two main classes of producer, from the up-country drying floor to the exporting vessel in Colombo, is not the same and, consequently, it was necessary for the inquiry to proceed

along two lines, one to trace the produce of the small-holder and the other that of the estates. The method of periodical sampling in each case is described in Dr. Fernando's article.

One interesting fact which has been disclosed in the course of the local inquiry is that the general belief that initial infestation of cacao beans by *Ephestia* in exporting countries takes place on the cacao drying-floor, is not substantiated under the conditions which prevail in Ceylon. It has been shown, however, that infestation may occur in this country during storage at all subsequent stages up to the time of shipment, both in the case of the product of well-managed estates as well as of that of the peasant-producer. For this reason, it is very necessary that all periods of storage should be curtailed to the lowest minimum possible and that the transit of the cured beans between producer and shipper should be accelerated. The prevalent practice of holding stocks in the hope of a market rise cannot be applied to this product if insect infestation is to be avoided or reduced. The investigation has demonstrated the liability to attack of cracked and broken beans, thus indicating increased care in curing to eliminate this source of attraction to the ovipositing moths. Finally, attention to places of storage will further reduce the risk of infestation. Wooden floors permit of an accumulation of cacao fragments in the spaces between planks and thus afford media in which the moths can develop. Where possible, such floors should be replaced by well-laid cement. In any case, frequent sweeping is essential and walls and ceilings should be whitewashed at regular intervals. Good lighting and ventilation are also required.

Although this world-wide investigation has been initiated by the manufacturers in England concerned, for their own purposes, it is very desirable that exporting countries should profit by the information which has been gained in the course of the inquiry. It is hoped that those in Ceylon who are associated with the cacao trade, whether they be growers, dealers, brokers or shippers, will give serious consideration to Dr. Fernando's article which describes an inquiry of considerable local importance and one which has been conducted in a particularly complete and efficient manner.

THE SOURCES OF EPHESTIA INFESTATION OF STORED CACAO IN CEYLON

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As far back as 1921, Knapp made mention of the tendency of Ceylon cacao to be " slightly grubby ". The percentage of insect-damaged beans in Ceylon exports at the time was in the neighbourhood of 2·0 per cent.; the average for the world's production was 1·6 per cent. The question of insect infestation assumed unpleasant prominence in 1934, when Ceylon's largest individual customer, the Philippine Islands, insisted on the fumigation against insect damage of all cacao imports from Ceylon.

The insects associated with the spoilage of stored cacao in Ceylon include the cacao moth (*Ephestia elutella* Hb.), the fig moth (*Ephestia cautella* Walk.), the rice moth (*Corcyra cephalonica* Staint.) and the Tephrosia beetle (*Araecerus fasciculatus* DeG.). In an examination by Munro and Thomson (1929) of 143 bags of Ceylon cacao received at the Port of London, 49 bags were observed to be infested with *E. elutella*, six with *C. cephalonica* and four (three doubtful) with *A. fasciculatus*. That species of *Ephestia* constitute the major pests of Ceylon cacao and, for that matter, of cacao from most parts of the world, is now generally appreciated.

Hutson (1932) estimates the duration under tropical conditions of the incubation period of the egg, the larval period, the pupal period and the total life-cycle of *E. elutella* at five to nine days, eight to ten weeks, nine to twelve days and ten to thirteen weeks, respectively. In cacao spoilage, it is of course the larval phase that is of especial interest. The *Ephestia* larva is unable to penetrate the hard shell of a fermented cacao bean and can invade only cracked and broken beans. The larva of *Araecerus*, on the other hand, is able to rupture the cacao shell and may accordingly prove an important accessory to *Ephestia* invasion. The *Ephestia* larva consumes the cotyledon substance of the bean, replacing it with characteristic frass, *viz.*, large fæcal pellets held together by fine webbing. Apart from cacao, the larva can subsist on an extremely varied diet, ranging from dried vegetables, tobacco, various kinds of seeds and cereals to the dead bodies of its own parents. These polyphagous habits make *Ephestia* control extremely difficult.

In 1936, the British Association of Research for the Cocoa, Chocolate, Sugar Confectionery and Jam Trades, London, in collaboration with the Department of Agriculture, Ceylon, initiated an investigation into the sources of *Ephestia* infestation of stored cacao in Ceylon, as an essential preliminary to the application of control measures. A description of the methods employed in that investigation and the results obtained are presented below.

EXPERIMENTAL MATERIAL AND METHODS

Ceylon has an acreage of approximately 34,000 under cacao (*The Ceylon Blue Book*, 1936). Nearly the whole of this area is in the Kandy, Dumbara and the Matale Districts. The trees are Forastero-Criollo hybrids. Ceylon cacao had, at one time, a large admixture of Criollo in its composition. Recent years have seen a gradual replacement of the Criollo strains by predominantly Forastero types. The main or autumn crop is ready for picking during the period November–January. A small spring crop is available in May, June and July.

Cacao plantations in Ceylon fall into two rather well-defined classes ; the large European-owned estates—a single estate of this type may cover as much as 2,700 acres—and the peasants' small-holdings averaging one to three acres each. A few estates owned by Indian Tamils constitute a class intermediate in type and extent. The small-holdings contribute nearly 70 per cent. of Ceylon's total output of cacao, and are accordingly of especial interest in the present connexion. The pre-fermentation history of small-holders' cacao has been described by Fernando (1938). The small-holder sells his cured cacao to a local petty dealer in quantities ranging from about 3 lb. to 30 lb. To carry the process of curing to completion ten to fifteen days may be necessary. Many villagers, however, sell their cacao after partially drying it for two to three days ; the drying is completed by the dealer. The local dealer's collections are allowed to pile up till their proportions warrant sale to a larger dealer. Small-holders' cacao passes through a relay of dealers of progressively increasing importance—nearly all of them Moors—till it eventually reaches a trader in the Pettah, Colombo. In the course of these successive transfers, the cacao is subjected to a considerable amount of bulking and grading, and to attempts at improving the complexion of the shell with annatto or brick-dust. Furthermore, this cacao remains in storage at each dealer's warehouse for periods varying from a few days to several weeks. When favourable market conditions obtain, the Pettah dealer sells his cacao to one of the large firms of European exporters. The cacao undergoes an elaborate process of regrading at the hands of the exporters, and is eventually shipped abroad.

Estate cacao follows a rather different procedure. The estate technique of cacao curing has been described by Fernando (1938). The cured cacao is subjected to elaborate hand-grading on the basis of bean-size, and is stored in bags till a sufficiently large bulk has accumulated, when it is transported to the estate agents in Colombo. During the height of the cacao season, the period of storage on the estate may not exceed two to three days. On receipt in Colombo, the cacao is either sold by the estate agents to a local firm of exporters or despatched directly abroad. In the event of the cacao passing into the hands of local exporters, it may be subjected to further grading and to further storage in anticipation of a rise in prices, before being finally consigned abroad.

It should be emphasized that, in some instances, the contents of a bag of estate cacao may remain untampered with during the whole of its journey from the estate to the foreign buyer. Small-holders' cacao, on the other hand, is heterogeneous from the start, and the series of bulkings and re-gradings that this cacao experiences prevents its retaining its individuality for any considerable period. The scheme of research drawn up by the British Association of Research for the Cocoa, &c., Trades consisted in the transport to the exporters' warehouse, in Colombo, of a bag of cacao beans collected from the growers' drying-floor, and the withdrawal at various stages in the transport of samples for examination for *Ephestia* infestation. Transport in this way of an experimental bag of small-holders' cacao does not reproduce the course normally followed by small-holders' cacao ; but the method serves the purpose of the present investigation, *viz.*, the determination of the sources of *Ephestia* infestation. It is conceded that the figures for the extent of *Ephestia* damage of small-holders' cacao provided by this method, will be an under-estimate.

The details of experimental procedure were as follows : In each series, about one cwt. of cracked and broken beans was selected from one or more drying-floors ; the broken shells predispose the beans to *Ephestia* attack. The beans were well mixed and a random 7 lb. sample was withdrawn, packed in an insect-proof tin and despatched for examination to the British Association of Research for the Cocoa, &c., Trades, London. The remainder of the cacao was sterilized by exposure to dry heat at 150°F. (65·6°C.), which temperature is lethal to all stages of *Ephestia*. A small electric oven with a capacity of 33,000 cc. was used. The sterilized cacao was placed in a bag of the type normally used for transporting cacao. This bag was subjected to the routine storage and transport. At selected points in the transport, further 7 lb. samples were withdrawn and the rest of the bag was sterilized at 150°F.

immediately after each sampling. Eventually the experimental bag reached the exporters' warehouse in Colombo. A last 7 lb. sample was removed and the remainder of the bag was finally sterilized almost immediately before its transference to the boat for shipment to the British Association of Research for the Cocoa, &c., Trades, London. It was possible, by an analysis of the series of samples, to reconstruct the story of the infestation of cacao in storage and transport. Sterilization by dry heat was preferred to sterilization by the use of fumigants as the latter might have had a residual repellent action upon *Ephestia*. Apart from a certain amount of dehydration, the heat treatment did not affect the cacao materially.

RESULTS

The collection of four series of samples—two series from the estates and two from the small-holders—was undertaken. Of the two estate series, one passed through a firm of exporters prior to shipment; the other series represented the type of estate cacao consigned directly abroad by the estate agents.

Estate Series 1.—The detailed history of this series is recorded below. The cacao belonged to the latter part of the small spring crop.

June 24, 1936.—One cwt. of cracked and broken beans was selected from a drying loft of the factory of Estate A. The age of the beans varied from ten days to one month from the time of picking. A 7 lb. sample (series 1, sample 1) was withdrawn.

July 1.—The remainder of the bag of cacao was sterilized and transferred to the estate stores. The store-room had 3,000 sq. feet of cemented floor-space and formed the ground floor of a four-storeyed building, the upper floors of which functioned as drying-lofts. The presence of drying lofts above and of an adjacent copra-dryer resulted in a rather high air temperature. Approximate estimates of average day temperatures of various floors were: ground floor 80°F., 1st floor 100°F., 2nd floor 120°F., 3rd floor 120°F. The store-room was well-lighted, well-ventilated and comparatively clean. Illumination and cleanliness of stores are of importance in view of the negative phototropism and the omnivorous habits of *Ephestia*. Copra was stored alongside the cacao.

August 17.—Sample 2 was withdrawn from the experimental bag which was then sterilized and despatched by rail, along with other bags of estate cacao, to the estate agents in Colombo.

August 21.—The bag arrived in Colombo.

August 22.—Sample 3 was withdrawn.

August 24.—The sterilized bag was transferred to the estate agents' warehouse, where it was stored along with other bags of cacao. A few damaged beans filled with the frass characteristic of *Ephestia*, were observed on the premises.

September 29.—Sample 4 was withdrawn.

October 3.—The sterilized bag was placed in storage in the warehouse of exporters.

November 9.—Sample 5 was withdrawn and the sterilized bag placed again in storage in the exporters' warehouse.

December 8.—Sample 6 was withdrawn and the sterilized bag placed again in storage in the exporters' warehouse.

December 15.—It was anticipated that the exporters would attend to the despatch of the bag. As the exporters' shipments were unexpectedly delayed, the bag was transferred back to the warehouse of the estate agents who undertook to forward the bag to London.

December 24.—The bag was removed from the estate agents' warehouse.

December 26.—The bag was shipped to London.

The results of the analysis by the British Association of Research for the Cocoa, &c., Trades, of the 7 lb. samples which constituted the above series are given in Table I.

The most noteworthy feature in the analysis is the apparent freedom of the drying floors from *Ephestia* infestation. The following experiment provided further evidence of the cleanliness of the drying floors. A representative 2 lb. quantity of cracked and broken beans removed from a drying loft of Estate A was incubated under conditions of protection from further insect infestation. Simultaneously two bags of cacao of about 1 cwt. each were drawn from the same source. One of the bags was sterilized at 150°F. Both sterilized and unsterilized bags were transferred to the estate stores on July 1, 1936. On August 19, random samples were drawn from each of the three treatments; each sample consisted of 700 unfragmented beans and $\frac{1}{2}$ oz. of fragmented beans. The results of the analysis of the three samples are given in Table II. The sample drawn from the drying-loft and protected from further infestation, showed no trace of *Ephestia* or *Araecerus*.

TABLE I

No. of Sample.	Sampling details.	Time from drying-floor in days.	Damage by* *Ephestia*	Presence of *Ephestia.*
1	Drawn from drying-loft	0	– –	Nil
2	After 47 days in estate store	54	+ (0·3%)	Nil
3	On arrival in Colombo	59	+ (0·3%)	Nil
4	After 35 days in warehouse of estate agents	97	+ (0·3%)	Nil
5	After 37 days in warehouse of exporters	138	+ (0·3%)	Nil
6	After further 29 days in warehouse of exporters	167	+ (0·3%)	Nil
	(Bag forwarded to London by estate agents after delay in shipment by exporters.)			
7	On arrival in London	229	+ (0·75%)	Live larvæ

* + Indicates damage, and – indicates absence of damage.

TABLE II.

Treatment	Number of beans damaged by		Number of *Ephestia*			Number of *Araecerus*		
	Ephestia	*Araecerus*	Larvae	Pupae	Adults	Larvae	Pupae	Adults.
1. Cacao drawn from drying loft and protected from further infestation	0	0	0	0	0	0	0	0
2. Cacao drawn from drying loft and exposed to infestation in estate stores	13	5	3	0	0	2	0	0
3. Cacao drawn from drying loft, sterilized and then exposed to infestation in estate stores	11	2	1	0	0	1	0	1

Estate Series 2.—Details of this series are recorded below. The cacao was collected towards the end of the small spring crop :—

July 9, 1936.—One cwt. of cracked and broken beans was removed from a drying-loft of the factory on estate B. The age of beans was one month from the time of harvesting. A 7 lb. sample (series 2, sample 1) was withdrawn.

July 16.—The sterilized bag was deposited at the estate stores. The factory on estate B was a three-storeyed building, the two upper floors of which served as drying-lofts. A verandah on the topmost floor functioned as the store-room The slatted wooden floor of the store-room differed from that of the adjacent drying-loft only in that it was not heated by hot air from the flue. The store-room was exceptionally clean, extremely well-lighted and ventilated, and had an average air temperature of 80°F.

August 28.—Sample 2 was withdrawn.

August 31.—The sterilized bag was despatched by rail to the estate agents in Colombo.

September 2.—The bag arrived in Colombo.

September 4.—Sample 3 was withdrawn.

September 7.—The sterilized bag was transferred to the warehouse by the estate agents.

October 12.—Sample 4 was withdrawn.

October 14.—The sterilized bag was transferred back to the warehouse of the estate agents.

October 24.—Sample 5 was withdrawn. The remainder of bag was left unsterilized on account of the short time available before despatch.

The results of the examination by the British Association of Research for the Cocoa, &c., Trades of this series of samples, are presented in Table III.

TABLE III.

No. of Sample.	Sampling details.	Time from drying-floor in days.	Damage by* *Ephestia.*	Presence of *Ephestia*
1 ..	Drawn from drying-loft ..	0 ..	— ..	Nil
2 ..	After 43 days in estate store ..	50 ..	— ..	Nil
3 ..	On arrival in Colombo ..	57 ..	— ..	Nil
4 ..	After 35 days in warehouse of estate agents ..	95 ..	+ ..	Live larvæ and dead adults
5 ..	After further 10 days in warehouse of estate agents and just prior to shipment ..	107 ..	+ ..	Live larvæ
6 ..	On arrival in London ..	174 ..	+ (1%)..	None alive

* + Indicates damage, and – indicates absence of damage.

Small-holders' Series 1.—The details of this series are given below. The cacao was collected from the early part of the main autumn crop.

October 23, 1936.—Nearly 1 cwt. of partially dried beans was secured in quantities ranging from 3 lb. to 33 lb. from drying-platforms of eight small-holders in Wattegama. The age of beans was about 3 days from the time of picking. The beans were thoroughly mixed and a 7 lb. sample (sample 1) was withdrawn. Sun-drying of the remainder was continued.

October 31.—Sun-drying of the cacao was completed. Sample 2 was withdrawn.

November 4.—The sterilized bag was deposited at the warehouse of a petty dealer in Wattegama. This type of dealer often buys imperfectly dried cacao from small-holders, and completes the drying operation himself.

December 12.—Sample 3 was withdrawn.

December 18.—The sterilized bag was deposited at the warehouse of a petty dealer in Kandy.

January 25, 1937.—Sample 4 was withdrawn. The sterilized bag was despatched to Colombo. Small-holders' cacao at this stage would normally have been transferred to the warehouse of a petty dealer in the Pettah, Colombo. Unfortunately, attempts at inducing petty dealers in the Pettah to handle this series failed.

February 2.—The bag reached the warehouse of the exporters. Sample 5 was withdrawn and the sterilized bag was placed in storage in the exporters' warehouse. A very large percentage of the cacao handled by this firm of exporters consisted of small-holders' cacao supplied by petty dealers in the Pettah. The quantity of cacao that passed through this firm was, however, relatively small. This firm dealt mainly in rubber and desiccated coconut, a considerable quantity of which was in storage in the warehouse at the time. The experimental bag was stored alongside cacao supplied by petty dealers in the Pettah. Some of this cacao was badly infested. On opening some of these bags *Ephestia* moths escaped. Many beans showed *Ephestia* damage. Illumination of the warehouse was poor.

March 8.—Sample 6 was withdrawn and the sterilized bag transferred back to the warehouse of the exporters.

March 22.—Sample 7 was withdrawn.

March 25.—The sterilized bag was transferred to the warehouse of another firm of exporters.

April 6.—The bag was shipped to London.

The results of the analysis of the above series of samples by the British Association of Research for the Cocoa, &c., Trades, is recorded in Table IV.

TABLE IV.

No. of Sample.	Sampling details.	Time from drying-floor in days.	Damage by* *Ephestia.*	Presence of *Ephestia.*
1†	Drawn from drying-floors	0	–	Nil
2	On completion of drying	8	–	Dead adults and pupae
3	After 38 days in warehouse of petty dealer in Wattegama	50	–	Nil
4	After 38 days in warehouse of petty dealer in Kandy	94	–	Nil
5	On arrival in Colombo	102	–	Nil
6	After 34 days in warehouse of exporters	136	+	Nil
7	After further 14 days in warehouse of exporters	150	+	Nil
8	On arrival in London	236	+	Nil

* + Indicates damage, and – indicates absence of damage.

† This sample was drawn before drying was complete and became mouldy during transit to London.

Small-holders' Series 2.—Details of this series are presented below. The cacao belonged to the latter part of the small spring crop.

August 29, 1937.—Nearly 1 cwt. of cracked and broken beans was collected from drying-platforms of small-holders in Ampitiya and Katugastota. The age of the beans was 3–5 days from the time of harvest. The beans were well mixed and a 7 lb. sample (Sample 1) was withdrawn. Sun-drying of the rest of the beans was continued.

September 6.—Sun-drying of the cacao was completed. Sample 2 was removed.

September 7.—The sterilized bag was deposited at the warehouse of a petty dealer in Katugastota.

October 15.—Sample 3 was withdrawn.

October 20.—The sterilized bag was deposited at the warehouse of another petty dealer in Katugastota.

November 27.—Sample 4 was withdrawn. The sterilized bag was despatched to Colombo.

December 2.—The bag arrived in Colombo. Sample 5 was withdrawn. The sterilized bag was transferred to warehouse of a petty dealer in the Pettah, Colombo.

January 11, 1938.—Sample 6 was withdrawn.

February 4.—The sterilized bag was shipped to London by a firm of exporters.

The results of the analysis of this series of samples by the British Association of Research for the Cocoa, &c., Trades, is given in Table V.

TABLE V.

No. of Sample.	Sampling details.	Time from drying-floor in days	Damage by* *Ephestia.*	Presence of *Ephestia.*
1† ..	Drawn from drying floor ..	0 ..	– ..	Nil
2 ..	On completion of drying ..	8 ..	– ..	Nil
3 ..	After 38 days in warehouse of a petty dealer in Katugastota	47 ..	+ ..	Pieces of adult moths of *E. cautella.*
4 ..	After 38 days in warehouse of another dealer in Katugastota	90 ..	+ ..	Nil
5 ..	On arrival in Colombo ..	95 ..	+ ..	Nil
6 ..	After 40 days in warehouse of dealer in the Pettah, Colombo	135 ..	+ ..	Nil
7 ..	On arrival in London ..	211 ..	+ ..	Nil

* + Indicates damage, and – indicates absence of damage

† This sample was removed before completion of drying and turned mouldy during transit to London.

DISCUSSION

The unsatisfactory state of the classification of the genus *Ephestia* has resulted in considerable confusion regarding the relative importance of various species of this moth in cacao infestation. Characters used for separating *Ephestia* species are either unreliable or involve elaborate micro-dissection. It has become customary to place *Ephestia* moths associated with cacao spoilage in the species *elutella* on account of the popular name "cacao moth" assigned to the latter. Results of recent investigations by Nicol (1935) suggest that *E. cautella* may probably prove as damaging a pest of stored cacao as *E. elutella*. *E. cautella* had hitherto been considered an unimportant pest of Ceylon cacao (Hutson, 1932). In the course of the present survey both *E. elutella* and *E. cautella* have been identified on Ceylon cacao, and it is likely the *E. cautella* is not as innocuous as was formerly supposed.

The most consistent feature in the four series was the apparent freedom of the drying floors from *Ephestia* infestation. In the first estate series, slight invasion occurred in the estate stores; the percentage of damaged beans after 1½ months storage was 0·3 per cent. No further damage was apparent till the bag of cacao left the exporters' warehouse. In the second estate series, on the other hand, the bag of cacao arrived in Colombo free from insect damage and from traces of insect life. *Ephestia* damage became evident only after the bag had remained in storage at the warehouse of the estate agents for about a month. The percentage of damaged beans in the bags belonging to the first and second estate series on arrival in London, were 0·75 and 1 per cent. respectively. The relatively low percentages are, at least in part, due to intermittent sterilization, and should not be considered valid estimates of the extent of *Ephestia* damage in cacao of estate origin.

Comparable results were obtained with the two small-holders' series. The cacao drawn straight off the drying-floor was free from insect damage. In the first small-holders' series, the sample drawn on completion of drying at the hands of the local petty dealer contained adults and pupæ of *Ephestia*. Despite the absence of *Ephestia* damage in the sample, this dealer's warehouse should be considered a seat of infestation. The cacao reached Colombo undamaged by *Ephestia*, and it was only after about a month's storage at the exporters' warehouse that visible injury occurred. In the second small-holders' series, *Ephestia* damage was evident after about a month's storage in the warehouse of the first petty dealer.

Most authorities have considered drying floors potential seats of *Ephestia* infestation. Knapp (1921), Patterson (1928) and Munro and Thomson (1929) among others, have entertained the possibility of drying-floor infestation. Noyes (1930) stated that moths deposit their eggs at night on beans exposed on drying platforms. (In Ceylon, at least, cacao is not left exposed on drying-platforms at night). Granato (1909) even reported the attack of cacao pods by *E. elutella* in Brazil. The apparent freedom from *Ephestia* of drying-floors of both estates and small-holders in Ceylon is accordingly of considerable interest. The cleanliness of small-holders' drying-floors and of estate barbecues where dehydration is effected by insolation, may, at least in part, be explained by the pronounced negative phototropism of both the larva and the adult of *Ephestia*. The relatively high temperatures occurring in estate drying lofts may possibly inhibit *Ephestia* development or may deter oviposition by the females. Exposure to a temperature of 55°C. (131°F.) for 40 to 45 minutes is lethal to all stages of *Ephestia* (Noyes, 1930). Lower temperatures may destroy stages of *Ephestia* other than the egg. All stages in storage subsequent to the drying floor—including warehouses of petty dealers, estate agents and exporters—may legitimately be suspected of being seats of *Ephestia* infestation. There is no evidence that infestation occurs during the actual process of transference between stores. As warehouse infestation is intensified by long storage, transport of cacao should be speeded up all the way from the estate to the boat. The practice of keeping cacao in storage till the advent of satisfactory market conditions should be discouraged. The periodic bulking and grading of peasants' cacao create conditions ideal for the distribution of the insect population throughout the beans. Estate cacao is more fortunate and there is a particularly high probability of its escaping infestation if shipped directly abroad by the estate agents; under these circumstances, estate cacao would escape contact with peasants' cacao.

In attempts at cleaning up seats of infestation, the preference of moths for the dark and for still air, and the not too fastidious feeding habits of the larva should be borne in mind. Too much emphasis cannot be placed on the importance of scrupulous cleanliness and of satisfactory illumination and ventilation of cacao warehouses. Warehouse floors should be frequently swept, and walls and ceilings frequently whitewashed. The floors should be of cement ; wooden floors accumulate quantities of cacao débris between boards. The marked seasonal periodicity of the cacao crop facilitates off-season cleaning up of cacao warehouses.

It has been suggested that this periodic clean-up may be advantageously supplemented by fumigation of warehouse interiors with hydrogen cyanide or ethylene oxide. But fumigation is not likely to be profitable if facilities for making warehouses airtight do not exist or if warehouses contain numerous crevices. *Ephestia* larvæ lodged in crevices may escape damage even when lethal concentrations of the fumigant occur in the more exposed situations. A further disturbing factor is the occurrence of what is sometimes known as " protective stupefaction " : larvæ which succumb to the immediate application of a certain concentration of fumigant may, if previously subjected to sub-lethal doses, resist a subsequent application of that lethal concentration (Potter, 1937). A rather more efficient method of sterilizing warehouses is the spraying of warehouse interiors with a solution of pyrethrins in a white oil. The sprayed interiors are provided with a protective film of insecticide which possesses considerable residual properties and prevents re-infestation. Spraying should be done twice a week during periods of moth emergence (Potter, 1938).

In instances where complete extermination is not practicable, the survival level of *Ephestia* may be lowered by the use of moth-traps ; tea made up in the usual way with milk and sugar provides an efficient lure. The possibilities of biological control by the use of the small Braconid wasp, *Microbracon* (*Habrobracon*) *hebetor* Say., which is predacious on species of *Ephestia*, may be profitably explored. Numbers of limp *Ephestia* larvæ paralysed by this Braconid may sometimes be seen on sacks of cacao. The liberation of these parasites in cacao warehouses has been advocated as a measure of *Ephestia* control. The life cycle of the parasite is conveniently short, and a single parasite can destroy several *Ephestia* larvæ. The fact that the larvæ which is the only susceptible phase of *Ephestia*, spends most of its days inside the cacao bean in a situation inaccessible to the parasite, interferes with successful control. It is only when the larva emerges from the bean prior to pupation, that it is exposed to

attack by the Braconid. For effective control it is essential to ensure a high population of parasites at this particular time (Noyes, 1930). Another parasite which shows considerable promise is *Trichogramma minutum* Riley (Chaboussou, 1937).

The orientation of sacks in storage appears to affect the degree of infestation to some extent (Wadsworth, 1933). The upper end of a bag stood end on, has a relatively large air space suitable for pupation of the larvæ and mating of the moths. Sacks should be stacked on their sides.

In Ceylon, both estate cacao and small-holders' cacao undergo vigorous washing at the end of the sweating operations. This washing contributes to the attractive appearance of the final product, but makes the shell brittle and consequently liable to *Ephestia* invasion. The risk of prejudicing buyers abroad would, however, prevent Ceylon growers from dropping the practice. Besides, the danger of moulding is considerably reduced by washing. The fact that Criollo beans are more susceptible to *Ephestia* attack than Forastero beans is of some interest in view of the present change-over from Criollo to Forastero types in Ceylon plantations.

One of the most promising recent developments in *Ephestia* control is use of leaves of neem (*Melia azadirachta* L.) as an *Ephestia* repellent. Sacks of cacao beans lined with air-dried neem leaves have been maintained free from *Ephestia* in a heavily infested environment. The neem appears to discourage oviposition by the females or to repel young larvæ. The leaves should not be mixed with the beans in the sack as this would necessitate re-winnowing (Anon., 1938).

SUMMARY

1. The methods employed and the results obtained in an investigation undertaken by the British Association of Research for the Cocoa, Chocolate, Sugar Confectionery and Jam Trades, London, in collaboration with the Department of Agriculture, Ceylon, into the sources of *Ephestia* infestation of stored cacao, in Ceylon, are presented.

2. The freedom from *Ephestia* of cacao drying-floors of both estates and small-holders, is demonstrated.

3. Stages in storage subsequent to the drying-floor, including warehouses of petty dealers, estate agents and exporters, are shown to be seats of *Ephestia* infestation.

4. Methods of *Ephestia* control are indicated in outline.

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THE INFLUENCE OF SPACING, RIDGING AND SEEDLING NUMBER PER HILL ON THE YIELD OF CHILLIES (CAPSICUM FRUTESCENS L.)

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CHILLIES and tobacco are the peasant's most important money crops in the Jaffna peninsula. Chillies are grown in the peninsula under irrigation, in rotation with paddy, tobacco, millets and cassava. Seedlings raised in nurseries are, when from four to six weeks old, transplanted into the field at the rate of two to four per hill. The hills are usually spaced 3 ft. by 3 ft. and are either on ridges or on the flat. Although certain well-established methods of cultivation are adhered to in the growing of chillies, little exact information exists regarding the relative advantages of various methods. This paper reports the results of an experiment designed to determine the effects of spacing, ridging and seedling number per hill on the yield of chillies. The experiment was set down at the Experiment Station, Peradeniya, during the *maha* season, 1938–39.

DESIGN OF THE EXPERIMENT

Treatments.—Details of the three sets of factors investigated, *viz.*, seedling number per hill, ridging and spacing, are presented in Table 1. The design of the experiment was factorial, *i.e.*, it included all possible combinations of the three sets of factors.

TABLE 1.

Seedling Number	Ridging	Spacing
N_0 : 2 seedlings per hill	.. R_0 : planting on the flat	S_0 : close—3 ft. × 2 ft.
N_1 : 4 seedlings per hill	.. R_1 : planting on ridges ..	S_1 : wide—3 ft. × 3 ft.

System of replication.—An experiment with complete replication of the eight treatments within each block would have had an undesirably large block size and a consequently large error variance. The adoption in the present experiment of the process of partial confounding permitted the reduction of both block size and error variance. By sacrificing part of the information on the three first-order interactions and the one second-order interaction, it was possible to secure an increase in the accuracy of the direct effect comparisons (Fisher, 1936 and Yates, 1933 and 1937). The distribution of the eight treatments over the four pairs of blocks of four plots each, is illustrated in Table 2.

TABLE 2.

Interaction confounded	N × R × S		N × R		N × S		R × S	
Block	IA	IB	IIA	IIB	IIIA	IIIB	IVA	IVB
Treatments	$N_0 R_0 S_0$	$N_1 R_0 S_0$	$N_1 R_0 S_0$	$N_0 R_0 S_0$	$N_1 R_0 S_0$	$N_0 R_0 S_0$	$N_0 R_1 S_0$	$N_0 R_0 S_0$
	$N_1 R_1 S_0$	$N_0 R_1 S_0$	$N_0 R_1 S_0$	$N_0 R_0 S_1$	$N_0 R_0 S_1$	$N_0 R_1 S_0$	$N_0 R_0 S_1$	$N_1 R_0 S_0$
	$N_1 R_0 S_1$	$N_0 R_0 S_1$	$N_1 R_0 S_1$	$N_1 R_1 S_0$	$N_1 R_1 S_0$	$N_1 R_0 S_1$	$N_1 R_1 S_0$	$N_0 R_1 S_1$
	$N_0 R_1 S_1$	$N_1 R_1 S_1$	$N_0 R_1 S_1$	$N_1 R_1 S_1$	$N_0 R_1 S_1$	$N_1 R_1 S_1$	$N_1 R_0 S_1$	$N_1 R_1 S_1$

A separate interaction is confounded within each pair of blocks. The second-order interaction N × R × S is, for instance, confounded between the components of the first pair of blocks, which accordingly provide no information on this interaction. Complete information on the interaction N × R × S is, however, contributed by the other three pairs of blocks.

Size of plot.—Each plot was 1/42 acre and contained four rows of hills spaced 3 ft. between rows and either 2 ft. or 3 ft. within rows. In the collection of data, a strip $4\frac{1}{2}$ ft. wide was rejected at each end of the plot. The nett area contributing data was hence 1/47 acre.

EXPERIMENTAL MATERIAL AND METHODS

The nursery.—Five cwt. of compost were spread over 570 sq. ft. (1/77 acre) of nursery bed and well mixed with the surface

soil in September, 1938. Seed of the variety Elephant's Trunk obtained from the Experiment Station, Jaffna, was sown in drills 3 in. apart.

Sowing Dates.	Quantities of seed sown.
September 16, 1938	8 oz.
„ 17, „	8 oz.
„ 28, „	1½ oz.

A certain amount of damping-off occurred in the nursery. The application of a 0·6 per cent. solution of potassium permanganate (1 oz. per gall.) at the rate of one quart per square foot of nursery bed appeared to check the disease. Seedlings corresponding to sowing dates September 16 and 17 were topped on November 3 ; the average height of the seedlings at the time was 7–9 in.

The field.—The experimental area had carried a crop of *Pennisetum typhoideum* Rich. during the *yala* season (March to July) 1938. The land was ploughed on October 3, 1938, and received an application of 11½ tons of compost per acre on October 11 and 12. The land was then disc-harrowed in two directions on October 13, and spike-harrowed on October 18. Plots set apart for ridge-planting were ridged with a ridging plough on November 5 and 6. Plots in which planting was to be on the flat were levelled on November 7. Seven-weeks-old seedlings were planted out in the field on November 7. It was found necessary to hand-water the area on November 15, as there had been no rain since the date of transplanting ; approximately one pint of water was applied per hill. Hand-watering was repeated on November 29 and December 9. The seedling stand was poor on account of the drought. Vacancies were supplied on November 17 and 18 and again on December 22. The unridged plots were weeded on December 1 and 2. The ridged plots appeared comparatively clean and were accordingly left unweeded. Flowering was first observed on December 6.

Incipient leaf-curl was effectively checked by spraying the plants on December 27 and 31, 1938, and on January 13 and 17, 1939, with lime-sulphur at a concentration of 1½ oz. per gallon. About 28 gallons of spray mixture were needed for the area.

Applications of sulphate of ammonia at the rate of 4 lb. per plot were made on January 3 and 4, 1939. The fertilizer was applied in pinches to the bases of the plants and forked in. The plots were harvested on January 1, February 2 and February 15.

METEOROLOGICAL DATA

Relevant rainfall records are presented in Table 3. Days of no rain are omitted.

TABLE 3.

Date	Rainfall in.	Date	Rainfall in.	Date	Rainfall in.
1938		1938		1938	
Sept. 16	·18	13	·02	17	·25
17	·55	14	·01	19	·13
18	·03	23	·42	20	·16
19	·28	27	·82	21	2·13
22	·94	28	·41	22	·06
23	1·33	31	·68	23	1·08
25	·24	Nov. 1	1·03	24	·42
26	·16	2	1·53	25	·25
27	1·13	3	·35	26	·21
28	·81	5	·49	27	·29
29	·66	6	·25	28	·10
30	·42	10	·01		
Oct. 1	·16	16	·35	1939.	
2	·03	17	2·57	Jan. 8	·09
3	·04	18	1·34	9	2·98
4	·26	19	·04	10	2·34
5	·22	21	·02	11	·01
7	·04	26	·06	12	·05
8	·48	Dec. 4	·10	17	·49
9	·62	7	·05	18	·76
10	·24	13	·19	19	·02
11	·01	15	·29	Feb. 15	·02
		16	·06		

RESULTS

Records of the vacancies provided estimates of the effects of various factors on the stand of transplanted seedlings. An analysis of variance of these records is presented in Table 4.

TABLE 4

Analysis of Variance of Numbers of Vacancies.

	D. F.	Sum of Squares	Variance
Blocks	7	47,667·75	6,809·7
Direct effects	3	217,382·3	72,460·8
Interactions	4	28,045·9	7,011 5
Error	17	59,476·55	3,498·6
Total	31	352,572·5	

The value of F for total treatments greatly exceeds the one per cent. point; the treatment effects are hence highly significant. The standard errors for the estimates of direct effects and interactions are $\sqrt{32 \times 3498 \cdot 6}$ and $\sqrt{24 \times 3498 \cdot 6}$ respectively.

Fisher's *t* test indicated that the effects of ridging and of seedling number per hill were significant at the one per cent. level. The various interactions and the effect of spacing were not significant. The results are presented in Tables 5 and 6.

TABLE 5

Numbers of Vacancies

(8/47 acre)

	Flat-planting	Ridge-planting	Means
Two seedlings per hill ..	313	483	398
Four seedlings per hill ..	961	2,074	1,517·5
Means	637	1,278·5	957·75

TABLE 6

Numbers of Vacancies

(8/47 acre)

	Flat-planting	Ridge-planting	Means
Close spacing	681	1,507	1,094
Wide spacing	593	1,050	821·5
Means	637	1,278·5	957·75

Yields in the experimental season were poor on account of the continued drought. It was not possible to take more than three pickings off the area. The total yields have been subjected to an analysis of variance in Table 7.

TABLE 7

Analysis of Variance of Yields

	D. F.	Sum of Squares	Variance	
Blocks ..	..	7	12,732·875	1,818·98
Direct effects ..	..	3	40,433·75	13,477·92
Interactions ..	..	4	7,270·5	1,817·6
Error ..	..	17	15,237·75	896·34
Total ..		31	75,674·875	

The value of F for total treatments greatly exceeds the one per cent. point and hence indicates significance. The standard errors for estimates of main effects and interactions are $\sqrt{32 \times 896 \cdot 34}$ and $\sqrt{24 \times 896 \cdot 34}$. The application of Fisher's *t* test showed that effects of spacing and of seedling number per hill were significant at the one per cent. level. The various interactions and the effect of ridging were not significant. The results are presented in Tables 8 and 9.

TABLE 8

Yields in cwt. per acre

	Flat-planting	Ridge-planting	Means
Two seedlings per hill	3·13	3·29	3·21
Four seedlings per hill	4·03	4·17	4·10
Means	3·58	3·73	3·66

TABLE 9

Yields in cwt. per acre

	Flat-planting	Ridge-planting	Means
Close spacing	4·35	4·60	4·47
Wide spacing	2·82	2·86	2·84
Means	3·58	3·73	3·66

DISCUSSION

Abnormal weather prevailed during the period of the experiment the results of which are accordingly of rather limited application. Monthly precipitation was well below the average for previous years, and the crop which was almost completely rain-fed was subjected to a protracted period of drought. The average yield over the experimental area was only 3·7 cwt. per acre.

In the statistical analysis of the records of vacancies, the significance of the effect of seedling number per hill is of little interest. A significantly better stand was obtained with flat-planting than with ridge-planting. The number of vacancies on the ridges was over double that on the flat. The increase in casualties consequent on ridging was estimated at 3,769 per acre. The poor stand associated with ridging was probably due to the occurrence, after transplanting, of a prolonged dry spell, during which plants on ridges, on account of their greater root exposure, would have experienced severer drought conditions than plants on the flat. Ridging did not produce a significant increase in yield and did not exhibit any incidental advantages that might have justified the extra expenditure incurred.

The effects of spacing and of seedling number per hill on yield were both significant and considerable. The closer spacing and the higher seedling number per hill produced increases in yield of 1·63 cwt. and 0·89 cwt. per acre respectively. The poor shoot and root growth consequent on the prevailing drought explains this association of increased yields with increase in plant number per unit area. It is probable that the repetition of this experiment in a wet season would reveal a significant interaction of season with spacing and with seedling number per hill.

SUMMARY

An experiment designed to determine the effects of spacing, ridging and seedling number per hill on the yield of chillies was laid down at the Experiment Station, Peradeniya, during the *maha* season, 1938-39.

The stand of transplanted seedlings on the flat was significantly superior to that on the ridges.

Significantly higher yields were obtained with the closer spacing (3 ft. by 2 ft.) and with the higher seedling number (four per hill), *i.e.*, increase in plant number per unit area was accompanied by increase in yield.

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A NOTE ON THE COCONUT CATERPILLAR IN THE BATTICALOA DISTRICT

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IN the old days, the coconut caterpillar in the Batticaloa District was an "annual affair", and nobody took very much notice of it. It made its appearance about June or July each year (during the "land wind" period), and faded out when the north-east monsoon came in. It did not do much damage, as it attacked isolated portions of the District only. But in 1920, the attacks became more serious and widespread, and the Entomological Division of the Department of Agriculture was consulted as to the best method of controlling this pest.

In 1921 the coconut caterpillar was declared a pest under the Plant Pests Ordinance, 1907, and the prescribed regulations required that the affected leaves should be cut and burned as soon as the pest made its appearance. The larger estates in the Batticaloa District carried out these instructions, but on a very large number of small estates owned by absentee proprietors, who kept only a kangany and three or four labourers on the estate, there was no supervision of these control measures, with the result that this work was seldom done by these small estates. The larger estates, therefore, found it useless to continue cutting and burning when their smaller neighbours did nothing to control the spread of this pest.

In 1934, when there was a severe recurrence of the coconut caterpillar pest, representations were made to Government by the Batticaloa District Agricultural Committee requesting that some more effective action should be taken. The Entomological Division of the Department of Agriculture then decided to try and control this pest by the breeding and liberation in large numbers of an introduced parasite *Trichospilus pupivora*. The regulations requiring the cutting and burning of infested leaves were temporarily suspended. The parasite was imported from South India and breeding stations, both at Peradeniya and Batticaloa, were started at the end of 1935. But owing to the difficulty of breeding this parasite in Batticaloa during the hot season, the Batticaloa breeding station was

closed down in September, 1936, since when parasites have been sent by post from Peradeniya to Batticaloa for liberation. During 1936, these parasites possibly contributed to the control of the pest, but the hot weather was rather too severe for them and probably only a few survived. In 1937, the outbreak of the coconut caterpillar was not so severe, but the liberation of parasites was continued. On this occasion they survived the hot weather better and the pest certainly abated. Moreover, the stoppage of the cutting and burning of affected leaves probably gave the local parasites a chance to increase and gradually to assist in the control of the pest, but it is doubtful if they could have done so unaided if the *Trichospilus* had not been introduced.

In 1938, the liberation of the *Trichospilus* parasite was continued in much larger numbers and it is hoped that, if the supply of this parasite is continued for a further period to give it every chance of acclimatizing itself to the Batticaloa District, it will assume the dominant position which it maintains in the western coconut areas in controlling the pest there. The damage done by the coconut caterpillar in this district when a severe and widespread outbreak occurs is very great, and it is estimated that a large proportion of the crop is lost for two years after one of these outbreaks. As coconuts and paddy are the two main-stays of the people of this district, the coconut caterpillar is a very serious obstacle to the well-being of the population.

Certain residents in this district, who expect rapid results to follow parasite introductions and consider that they should lead to a complete disappearance of the pest they are designed to control, are of opinion that the introduction of *Trichospilus* into the Batticaloa District has not met with successful results. It is doubtful, however, if any pest can be completely suppressed by such methods, and, at best, only periodical control over long intervals can be expected. As a practical planter of some 17 to 18 years' standing in this district, it is my opinion that the introduced *Trichospilus* parasite, although by no means entirely responsible for controlling the coconut caterpillar pest in the Batticaloa area, is playing its part in helping the local parasites to bring about this satisfactory result.

SELECTED ARTICLES

CONCLUSIONS AND RECOMMENDATIONS OF THE CONFERENCE OF COLONIAL DIRECTORS OF AGRICULTURE, HELD AT THE COLONIAL OFFICE IN JULY, 1938*

1. THE WORK OF THE IMPERIAL AGRICULTURAL BUREAUX

THE Conference desires to place on record its high appreciation of the work of the Imperial Agricultural Bureaux and of the Imperial Institute of Entomology and the Imperial Mycological Institute, and has no suggestion of major importance to make concerning the manner in which their functions are performed so far as the Colonial Empire is concerned.

It is, however, suggested that consideration might usefully be given to the possibility of providing somewhat fuller abstracts of papers which appear in publications which are normally difficult of access to workers in the Colonial Dependencies or which appear in languages with which British workers are unlikely to be familiar.

It is thought that a useful purpose would be served if arrangements could be made to supply those in charge of the Institutes and the Bureaux with lists of the publications which are normally received and filed in the Colonial Departments of Agriculture and Veterinary Services as this would afford guidance as to the amount of abstracted matter which should be provided in respect of articles appearing in particular publications.

It is also suggested that such lists could be interchanged with advantage between the various Colonial Departments as they would serve to guide the departmental authorities in the choice of publications desirable for departmental use.

The Conference further desires to express the high appreciation of Colonial workers of the critical reviews of certain aspects of agricultural research which have been from time to time issued by certain of the Bureaux and to suggest that so far as circumstances permit the continued issue of similar reviews would be welcomed by Colonial workers.

II.

In connexion with the work of the Imperial Bureaux the Conference desires to invite attention to resolution XXXIV of the Commonwealth Scientific Conference which relates to co-operation in obtaining and maintaining plant material for crop improvement.

* Extract from the *Report and Proceedings of the Conference of Colonial Directors of Agriculture*, Colonial Official Publication No. 156.

The Conference is of opinion that it is most desirable that colonial research workers should be placed in a position to know the sources from which material of the recognized varieties of cultivated crops could be obtained and the nature of the varieties available.

To this end it is recommended that the Executive Council of the Imperial Agricultural Bureaux or other suitable authority should consider the possibility of taking steps to cause lists to be prepared of the recognized and established commercial varieties of the more important tropical and sub-tropical crops grown in the different territories in the Empire, and to include therein brief descriptions of the characteristics of each variety and an indication as to the sources in each territory from which planting material would be available to research workers engaged in plant improvement problems.

III.

The Conference also desires to invite attention to Resolution XXXVI of the Commonwealth Scientific Conference which relates to the control of damage by termites.

The Conference stresses the importance of active measures being taken to control the losses being occasioned by termites in the Colonial Empire and expresses the hope that the Executive Council of the Imperial Agricultural Bureaux may be able to take such steps as will lead to the collection and interchange of information on the lines recommended by the Commonwealth Scientific Conference at as early a date as may be possible.

In particular it is desirable that material showing the various stages of the development of the different species of termites which occur in the Colonial Empire, together with an account of their distribution and the character of the damage done by them, should be submitted to the Imperial Institute of Entomology, with a view to establishing the species which should be regarded as dangerous and destructive and to determining their distribution.

The Conference desires to lay stress on the importance of securing the active collaboration of other Government authorities with the official Entomologists in termite investigations and particularly that of the Public Works Departments.

2. SOIL CONSERVATION

The Conference recognizes that the importance of soil conservation cannot be over-stressed. Increased attention has been given to this matter in recent years throughout the Colonial Empire and a sound public opinion is being formed in favour of soil conservation, the prevention and check of accelerated erosion and the maintenance of soil fertility. In many Colonial dependencies active steps have been taken to check accelerated erosion and further action is contemplated. It is recognized that the chief asset of the colonial peoples is the soil and that economic policy requires to be planned on soil fertility and productivity.

Accelerated erosion takes place when there is an interference with the vegetative cover and it is necessary to recognize that lands should be utilized for

the purposes for which they are best fitted, due regard being given to the maintenance of adequate forest and grass cover, especially in hilly districts and for the protection of the springs and water supplies. Nature dictates that some lands should always be maintained in forest cover, others are suited for grassland development whilst others are fitted for cultivation.

Ecological surveys should be a preliminary to the planning of land utilization and where development has progressed general agricultural and economic surveys are also desirable as a necessary preliminary to schemes designed to improve conditions or to introduce new systems of husbandry, which aim at increasing soil fertility or the improvement of soil structure. The Conference is of the opinion that further investigational work is necessary to ascertain the scientific causes of crumb formation and of those factors which lead to soil stability.

In agricultural practices attention should be given to all measures designed to effect soil stability, improve fertility and check erosion. These measures must vary with circumstances, with the differing characters of soils and climatic conditions and with the crops under cultivation. Some crops are liable to induce accelerated erosion more readily than others and in agricultural practices the aim should be to encourage contour ploughing or planting and the development of a satisfactory land cover at least during the periods which are dangerous from an erosion point of view.

Erosion occurs in widely varying forms in different types of country, each calling for the application of measures which may be found to be locally suitable. These measures should naturally be designed to slow down the movement of soil by either wind or water by every economic means possible and should include the protection and restoration of vegetation and the erection, where necessary, of structures to slow down and spread the movement of water.

Importance is attached to the use of vegetation control in attempts to check erosion and the Conference desires to record its opinion that simple measures should always be explored before works of an engineering character or of a costly nature are contemplated. Schemes of erosion control should be based upon drainage areas and work should invariably start at the head of the natural drainage channels or at the sources of the erosion trouble. The maintenance of forests or other vegetative cover on high lands and at the heads of natural drainage channels is of the utmost importance.

The Conference recognizes that soil conservation work is the duty of all and that it is unlikely to be successful, owing to the varied and far-reaching problems involved, unless a policy of close co-operation is established between the Administration, all technical departments of Government, all local Authorities and the people. It desires to emphasize that it is essential to get down to the people themselves in order to arouse their interest in the problems and to secure their willing collaboration. The creation of an informed public opinion is an essential to success. Collaboration and co-operation may be effected by the formation of local Committees and the direct interest of the people may be aroused by the establishment of good demonstration areas of adequate size at well selected and important centres. In these demonstration areas it is necessary not only to show how anti-erosion measures can be successfully

carried out but to demonstrate the proper utilization of land and the methods of crop and animal husbandry designed to assist in soil conservation and the maintenance of fertility. The development of sound systems of agriculture is as essential in soil conservation work as are measures against erosion, even in areas where erosion is already assuming serious proportions.

The importance of dams to intercept run-off cannot be over-emphasized and the Conference has noted with satisfaction the valuable results which have been achieved in Basutoland as a consequence of the creation, as part of the scheme for erosion control, of small dams and the establishment of terraced fruit and vegetable gardens. In pastoral areas the importance of improved and increased water supplies also cannot be overstressed : the creation of such supplies assists in the better utilization of the pastures.

The conference wishes also particularly to emphasize the important role which Administrative Officers should play in all matters connected with the planned utilization of lands and soil conservation control. On them falls the duty, in collaboration with technical officers, of arousing interest amongst the agriculturists or pastoralists in the erosion problems with which they are faced, in stimulating the effective working of local committees, in encouraging effective co-operation and in smoothing out the difficulties which face technical officers charged with soil conservation duties. It recommends also that the subject of land utilization and of soil conservation and the part which Administrative Officers can play in these matters should take an important place in the courses provided at Oxford and Cambridge during the training period for Administrative Officers prior to their assumption of duties in the Colonial Service. It is suggested that in these courses the wide and important nature of the subject should be emphasized and the necessity for the fullest co-operation between all branches of the Colonial Service stressed.

Technical officers with experience in soil conservation work are necessary in many of the Colonial dependencies for executive duties and for effecting liaison between the several departments and between those departments and Administrative Officers. The Conference is of the opinion that the best interests will be served if these officers are regarded as liaison officers rather than purely executives. Work on soil conservation and even work connected with anti-erosion measures concern a large number of departments and an even greater number of individuals. It would be impossible to expect satisfactory progress if executive works were entrusted solely to soil conservation officers as their numbers could not be adequate to the task which has to be faced in the Colonial Empire. Officers with specialist knowledge of and experience in soil conservation measures are essential to progress and all plans formulated by local committees or by departments should be examined and approved by competent technical authorities before they are put into operation.

The value of an interchange of visits is emphasized and the Conference recommends that provision should be made for officers concerned with soil conservation to visit neighbouring territories or even farther afield in order to study measures which have been adopted to deal with erosion or with other matters concerning the conservation of soil and its fertility. It also feels that

farmers engaged in soil conservation operations should be enabled to exchange visits from time to time and that organized visits by them to demonstration areas should be arranged.

In the matter of de-stocking the Conference recognizes that this may be necessary in certain areas where soil erosion has assumed serious proportions and where stock concentrations are high, but it does not overlook the difficulties which have to be faced. The education of responsible leaders on the need for de-stocking under certain conditions is regarded as being the first essential, and it is felt that progress in the development of a public opinion in favour of stock reduction will follow efforts to establish a commercial outlet for stock and animal products. Efforts in this direction may include the development of great numbers of market centres and the encouragement of butchers' shops at these centres and elsewhere. An increase in the centres for drying hides and skins is also necessary in some areas and, as far as cattle are concerned, the development of dairy undertakings and the preparation of ghee should be encouraged. Improvement schemes designed to enable the stock owners to secure from a reduced number of good, well-fed stock a financial return which is not less than that previously obtained from a large number of ill-fed inferior stock are certain to secure results in the long run and the denudation of the countryside caused by trampling and over-grazing will be reduced.

Pasture management plays an important role in soil conservation in grass land areas and the importance of controlled movements of stock and of controlled grazing is considered to be of the greatest importance under such conditions.

In all areas the Conference desires to express the opinion that there is a necessity for some measure of control over grass or bush burning, and that such control measures as are desirable should be established when the necessary preliminary investigational inquiries have been made.

3. ANIMAL HUSBANDRY

The Conference desires to emphasize the importance which animal husbandry must play on the development of systems of mixed farming, the value of which cannot be overstressed if soil fertility is to be maintained and the nutritional standards of the inhabitants of Colonial Dependencies improved.

The Conference recognizes the valuable progress which has been made with mixed farming in the Northern Provinces of Nigeria and notes the experimental work which is being done with mixed farming in several other parts of the Colonial Empire. The trials which have been initiated recently in the Wet Tropics were recognized as being of the greatest importance and the results secured from the use of farmyard manure on Benin sands in Southern Nigeria and in other areas are of importance. It is urged that further efforts should be made to test the feasibility of the introduction of animal husbandry into the agricultural systems of the wetter areas. Interest was taken in the successful results obtained from the folding of sheep in certain parts of the forest area of the Gold Coast and in the value which followed the keeping of poultry in citrus cultivations in some areas. It is recognized that there were considerable

difficulties in effecting the introduction of animal husbandry in many areas and that the question of disease required careful consideration. In the wetter tropics it is recognized that open grazing may be difficult, and under these conditions the stall feeding of stock with forage and fodder crops provides a better alternative than grazing.

The Conference also suggests that increased attention could with advantage be paid to the part which buffaloes can play in the Wet Tropics and recommends that future work should include trials designed to ascertain how far buffaloes both of the milch type and also of the working type can be successfully employed in suitable regions in the development of mixed farming.

It is felt that extensive preliminary experiment is always necessary before mixed farming is introduced and that provision for the training of cultivators in the new methods and for establishing the more progressive of them, after training, as groups of demonstrators is essential to success.

The question of finance for the provision of the necessary stock and implements is a matter which requires special consideration and the Conference expresses the view that some provision must be made for reasonable financial assistance to selected individuals and that means should be devised to enable prospective "mixed farmers" to effect savings through co-operative thrift societies or by other means against the necessary purchases of stock and implements. It also feels that the amounts of loans and the terms of repayment should in general be in direct relation to the capacity of the farmers to repay.

Government assistance, after experimental work had been done and the necessary training provided, could in the view of the Conference best take the form of—

(1) The provision of water supplies in centres where mixed farming is being started.
(2) The provision of instructional agricultural services.
(3) The provision of reasonable financial assistance for the establishment of trainees on their holdings.
(4) The encouragement of thrift societies.
(5) The provision of adequate supplies of selected and trained stock at the lowest possible prices.
(6) The provision of implements at the lowest possible prices.
(7) The provision of veterinary services for the immunization of stock required by mixed farmers and for detection of disease and attention thereto when it occurs amongst the stock maintained by them.
(8) The development of market centres and of schemes for the orderly marketing of produce.

4. NUTRITION.

With a view to effecting a general improvement in nutrition, the Conference recognizes the importance which should be attached to increased attention being given by all Colonial Departments of Agriculture and Veterinary Services to the development of animal husbandry, the encouragement, where practicable, of mixed farming, and to the production of greater supplies, and to the greater diversification, of locally grown foodstuffs.

The nutritional problem in the Colonial Empire is basically economic and agricultural, and it can only be tackled satisfactorily if there is the closest co-operation between the Medical, Agricultural, Veterinary and Education Departments.

Generally speaking there are definite indications that emphasis should be given to the greater consumption throughout the Colonial Empire of meat and other animal products, fruit and green vegetables.

A greater consumption of meat can often be secured by increasing the number of butchers' shops and in some areas it has been found that a greater consumption of milk has followed schemes for the development of mixed farming and for the production of ghee. Milk, from which the fat has been extracted for sale, if returned to the producers at the time of separation, will, it has been proved, be taken back for consumption in the homes, the occupants of which would otherwise not have secured the milk at all, but have allowed it to be consumed by suckling stock. The development of poultry keeping also offers possibilities of considerable development, whilst there is in some areas a serious lack of fruit supplies and in certain seasons a dearth of green vegetables. Leafy spinaches and indigenous vegetables form an important part of native dietary and the Conference considers that Departments of Agriculture could profitably give greater attention to the development of vegetable gardens, especially where water supplies are available.

The Conference agrees with the suggestion that endeavours should be made to encourage the use of under-milled or good quality par-boiled rice in the place of polished white rice in all territories where rice is the staple food of diet.

It also desires to place on record that in its view the improvement of nutritional standards will follow, as has already been frequently demonstrated in many areas of the Colonial Empire, an improvement in the economic position of the people concerned, and that it is essential that the production of commercial cash crops or animal products should continue to be encouraged, in addition to the production of greater local supplies of food, if progressive improvement in the nutrition of the peoples concerned is to be achieved.

5. LAND SETTLEMENT

The Conference has taken careful note of the observations submitted on the subject of land settlement in the Colonial Empire, and of the steadily increasing importance which is being attached to this form of development as a means of providing a solution of certain social problems of pressing importance, particularly in the Caribbean area.

It feels that if development is planned along lines, the nature of which is now becoming reasonably well recognized, land settlement can do much to provide an alleviation of certain social difficulties. There are, however, limits to the possibilities of land settlement and failure to appreciate and to take account of these can only lead to disappointment and failure.

The Conference desires to stress that in all schemes of land settlement careful consideration must be given to the selection of the land and that this must be chosen by reason of its suitability for cultivation from an agricultural point

of view, its accessibility to transport facilities and to market centres. The existence of suitable provision for water supply is essential and in malarial districts steps to improve health conditions must not be overlooked.

Great importance attaches also to the selection of settlers, while provision must be made for their training after selection.

The system of tenure adopted is also of importance and whilst freehold tenure has been and is still, in certain quarters, extensively advocated, it should not be overlooked that continued supervision of the settlers by qualified officers is necessary if satisfactory results are to be achieved. Unsupervised settlement and the unrestricted possession of lands by peasant owners frequently results in unsatisfactory methods of cultivation, to fragmentation of holdings and the ultimate frustration thereby of settlement schemes. In this connexion it is emphasized that if land settlement is to be a source of permanent improvement and not merely a temporary palliative of existing difficulties it is necessary to take a long view and to plan accordingly.

The Conference considers that in all schemes it is necessary to pay the most careful attention to the systems and methods of agriculture employed and that those responsible for the supervision should be in a position to insist on the holders following cultural practices which will so far as possible ensure that the fertility of the soil on the settlement is adequately conserved.

The Conference further desires to stress that from the point of view of general efficiency a collection of small holdings is usually less efficient agriculturally than a large estate, and consequently it is desirable that a measure of co-operation should be applied in regard to the purchase of farming requirements, the provision of implements, stock and buildings and the preparation and marketing of produce.

It also desires to indicate that successful land settlement is often costly and although a part of the initial outlay may be in time recouped a proportion of non-recoverable expenditure on land settlement schemes has to be faced.

Particularly it desires to emphasize that in planning land settlement schemes due account must be taken of the crops which can be cultivated by the tenants and the markets which can be found for the produce. All schemes should include the production of as large a proportion as possible of the food requirements of the tenants themselves but there must also be included at least one cash crop if the holders are to be expected to achieve a reasonably adequate standard of living.

The Conference considers that as a prelude to the inception of land settlement schemes a survey of the economics of peasant agriculture is of the greatest value and urges that wherever possible such surveys should be undertaken before developments are embarked upon, and that when this is not possible a careful economic examination should be made of the data available.

All attempts to launch land settlement schemes without due consideration of the factors involved or the examination by the agricultural authority as to the suitability of the lands for development are to be deprecated. It is felt that there have been sufficient examples in the past of the folly of establishing land settlement schemes on unsuitable lands without adequate preliminary

inquiries or without the provision of continued instruction for the settlers. All feasible steps it is recommended should be taken to avoid a repetition of these mistakes in the future.

6. PRODUCE INSPECTION

The Conference has noted with interest the progress which has occurred in the development of schemes of inspection of agricultural produce in a number of dependencies since the last Conference in 1931.

It feels that in territories and under conditions where there is an opening for their operation the further development and extension of such systems should be considered.

Particular attention is directed to the striking measure of success which has attended efforts in this direction in certain African Territories and it is noted with satisfaction that the necessity of providing for the continuation of the service on a permanent basis in Nigeria has now been accepted.

The Conference desires to emphasize that an essential to the success of schemes of Produce Inspection lies in securing the support for them of trade interests. In Nigeria this has been secured by appointing to the Advisory Committees members of merchant firms interested in the purchase and shipment of produce.

When lack of success has occurred it is traceable in some instances to insufficient collaboration with commercial interests and to lack of propaganda designed to explain the objects of the inspection schemes to the producers prior to their introduction.

It further seems clear that Produce Inspection is only likely to produce satisfactory results where the improvement in the quality of the produce which it is sought to bring about is in accordance with the recognized demands of the market. Consequently an essential preliminary to the inception of new schemes should be the careful examination of the market requirements in regard to quality and where grading is undertaken the grades which are established should be in accordance with market standards.

Instances do, however, exist where attempts to improve the quality of exported produce may meet with success by reason of the fact that it will tend to reduce the losses which badly prepared produce is liable to undergo during storage and transit.

7. AGRICULTURAL EDUCATION AND TRAINING

The Conference has noted with satisfaction the general progress that has been made in the development of training in agriculture for adolescents and adults and the steps which have been taken to provide for the training of staff for the requirements of Departments of Agriculture.

An exchange of views at the Conference indicated the nature of the main difficulties which are experienced in regard to vocational training for adolescents and adults under the varying conditions prevailing in the Colonial Empire.

Elementary education in certain territories still stops at an early age and consequently youths who proceed from elementary schools to agricultural courses complete their vocational training before they are ready to start agricultural enterprises on their own account. There is a decided difficulty in bridging the gap between the completion of their agricultural training courses and the time when they can establish themselves as farmers. Attention is being given to this problem in some dependencies.

The Conference is fully in accord with the general policy adopted in regard to community education and agrees that training centres for teachers and instructors should be located in rural areas wherever possible alongside those provided for forestry, veterinary, health and other subjects. Stress should be laid on the necessity for securing improvement in general living and working conditions in rural areas and efforts should be directed towards making rural life more attractive.

Supervision of students who have received vocational training is, in consequence, important and the Conference records the view that the importance of " follow-up " work cannot be over emphasized.

Definite progress in the training of subordinate staffs for Departments of Agriculture is recorded but the Conference attaches importance to steps being taken to ensure that scholars, especially those in receipt of bursaries or scholarships from public funds, admitted to vocational agricultural schools or colleges have a rural background or outlook.

The Conference welcomes the steps which are being taken by the authorities of the Imperial College of Tropical Agriculture to provide special courses of training for selected subordinate officers in Colonial Departments of Agriculture with a view to fitting them for promotion to higher staff appointments.

The Conference further welcomes a growing measure of co-operation between the agricultural and education departments, and hopes that it will become increasingly fruitful.

8. PROPAGANDA AND PUBLICITY

The Conference desires to record that close attention to propaganda and publicity is necessary if satisfactory progress in extension work is to be achieved. It has examined the different systems in operation and concludes that the use of films and, in certain dependencies, broadcasting can form a useful adjunct for reinforcing normal extension activities and of attracting attention to them.

Films, for the purposes of agricultural propaganda and instruction, may be divided into three classes :—

(*a*) General interest films designed to secure the interest of the audience.
(*b*) Background films depicting familiar local scenes and operations designed to provide a background for more detailed instruction.
(*c*) Films aiming at detailed instruction in agricultural processes.

The Conference notes that up to the present time experience in certain dependencies appears to indicate that, with regard to category (*c*), detailed

instruction in agricultural processes is better conveyed by means of still lantern pictures with a spoken commentary, but that there is need for further experiment on this point, while films under categories (*a*) and (*b*) appear to be valuable as an adjunct to detailed instruction whether by films or by slides.

The Conference considers that films under categories (*b*) and (*c*) can serve a useful purpose only if they are prepared with a precise regard to local circumstances and conditions, *i.e.*, that in general they should be prepared locally or under local guidance from technical departments. The Conference further believes that it is in general practicable for Colonial Governments to prepare reasonably satisfactory films of this nature locally without importing expensive professional assistance. The possibility of securing help from selected amateurs interested in cinematography and professional assistance when it can be obtained cheaply should not be overlooked.

In any case propaganda or publicity through the medium of the film or broadcasting requires to be "followed-up" intensively by extension workers if it is to secure a lasting measure of success and the Conference attaches importance to demonstrations and lectures at district shows, village council meetings and schools and to the organization of visits to agricultural and demonstration stations and selected farms.

THE DEVELOPMENT OF THE CASHEW-NUT INDUSTRY IN INDIA*

INTRODUCTION

MANY tropical fruits of economic importance hitherto unknown are now absorbing the attention of the grower as well as the commercial man. For instance, within a generation, the banana (*Musa* species) has passed from a rare luxury to a staple food product, the pine-apple (*Ananas sativus*, Lindl.) from a little known fruit to an important one which is now sold in millions of cases of fresh and canned fruit from the Hawaiian Islands. The cashew-nut (*Anacardium occidentale*, Linn.) which is no less important than banana and pine-apple has been until recently miserably neglected as it was not deemed of much value as an article of consumption or purposes of trade. Like other forest trees, the cashew-nut tree also suffered from the axe of the foresters causing a serious national drain. With its recognition as an article of consumption as well as one yielding several by-products of economic importance which promises the development of international trade, the cashew-nut is now receiving the serious attention of the grower and the commercial man, who have begun to take up its cultivation and develop internal as well as overseas trade.

The cashew-nut received further fillip by its growing popularity in the confectionery trade of America and Europe. As a result of this, a flourishing export trade in cashew kernels has now been established on the east and west coasts of India.

The outbreak of the World War in the year 1914, however, considerably hindered the export trade of this commodity but the post-war period saw it gradually reviving and a brisk foreign demand is now reinforced.

The export trade in the cashew-nut received still further impetus by the establishment of Cochin as the chief exporting centre in South India, which draws produce from the neighbouring places of Malabar and the States of Cochin and Travancore. This present position which this commodity occupies augurs well and it is hoped that the trade for products, whose economic value has been hitherto indifferently appreciated on the east and west coasts, would further develop rapidly with other European countries besides America who is at present our chief customer.

GEOGRAPHIC DISTRIBUTION

The cashew-nut has become thoroughly acclimatized and found a congenial home in Southern India in the dense forests along the west coast. In South Kanara which is the largest producing centre in India, the cashew-nut tree

* By I. A. Sayed, B.Ag., College of Agriculture, Poona, in *Agriculture and Livestock in India*, Vol. IX., Pt. I., January, 1939.

grows very extensively in a wild state mixed with the mango (*Mangifera indica*. Linn.) and other forest trees and shrubs all along the hill slopes where, owing to the poor soil and exposed situation, it attains a low bushy form. The cashew-nut is abundant and densely scattered all over the low hilly ridges of the Goa territory where it yields a handsome revenue from the nuts and its by-products. Similarly on the east coast, it is abundant in places like Guntur, Godavari, and Vizagapatam Districts. It is also reported that Burma produces a very large quantity of raw nuts but for lack of facilities for collecting and transporting its produce is being practically wasted.

CULTURAL REQUIREMENTS

The cashew-nut is not fastidious about soil conditions in which it grows. It easily adapts itself to varying soil and water conditions without impairing its productivity. It thrives best on sandy soil in the neighbourhood of the sea. The tree is intolerant of frost. It withstands drought remarkably.

The satisfactory feature of the cashew-nut plantation is that it does not involve a heavy capital out-lay as preparatory tillage, manuring, &c., can be dispensed with. However, the tree is considerably benefitted by systematic cultivation.

The cashew-nut tree does not stand transplanting and, therefore, the seeds are sown fresh *in situ* in June spaced at fifteen feet apart. Thus 193 plants are stocked in an acre. The tree commences to bear after three years and continues for abour fifteen to twenty years although instances of trees bearing for over thirty years are not uncommon. Thereafter, the tree exudes a gummy substance and renders it unfruitful. The crop ripens in summer.

The fruit or the nut which is about one inch in length and kidney shaped develops upon the pyriform fleshy body which is three times as large as the nut. The " apple " as it is termed, assumes red and yellow colour on ripening and is formed by the enlargement of the disc and top of the peduncle. The " apple " is two inches to four inches long, almost full of juice, slightly acidic and is often used in preserves.

A fifteen to twenty year old tree yields annually on an average 150 lbs. of apples and 20 lbs. of raw nuts. This yield when commuted to money value works out as follows :—

	Rs.	A.	P.
1. 150 lbs. of apples sold at 100 per anna	0	12	6
2. 20 lbs. of nuts yielding 2 lbs. of kernels sold at 2 lbs. per rupee ..	1	0	0

Income from apples is always doubtful as, at present, their utilization for the manufacture of liquor, vinegar, &c., is negligible. The income from the nuts is always certain.

PRODUCTS OF THE CASHEW-NUT

The cashew-nut tree yields several economic products but the principal ones worthy of mention are (*a*) the kernels of the nuts, (*b*) a liquor distilled

from the fermented juice of the apple, and (*c*) the oil obtained by roasting the pericarp of the nut. It is, however, regretted that with the exception of the kernels, the other two have hitherto been not exploited successfully in spite of the knowledge that in them also lies the potential source of income to the grower and revenue to the State. These products will be dealt with in the order of sequence.

(*a*) THE KERNELS OF THE CASHEW-NUT

The importance of the cashew-nut industry in India at present lies in the value of its kernels which are exported in considerably large quantities to the United States of America and to a small extent to the continent of Europe where they are utilized in the confectionary trade. The kernels are required to be shipped without shells, properly processed as they are not edible in raw state.

"PROCESSING" OR CURING OF THE CASHEW-NUT

Curing is done by roasting the nuts which causes the shells to split, thereby facilitating the removal of shells from the nuts. The roasting operation has to be done with caution as oil contained in the pericarp gives out vapours which are injurious to the human face and the eyes.

The following operations are involved in the processing of cashew-nut :—

1. *Roasting.*—The factory owners (Sayed, 1931) according to the magnitude of output, purchase raw nuts either locally or import from other parts of India and outside it. The nuts are brought to an open drying yard and spread evenly for uniform drying. On complete drying, the nuts are roasted in an open iron pan placed on a circular earthenware furnace erected three feet above the ground and fed by the cashew-nut shells. The roasting pan which is three feet long and two feet broad and has a lever and counter weight arrangement is fed with a small quantity of nuts (20 to 30 lbs.) each time and stirred vigorously by means of long iron ladles for a minute or two. A little water is sprinkled over the nuts to extinguish the fire burning the shells and are immediately thrown aside by means of simple lever adjustment. This operation is carried out by two men. The daily (six hours) output of roasted nuts amounted to 6,720 lbs. Women, not more than three, before collecting the roasted nuts for shelling, sprinkle ashes over them to dry out the oil which would otherwise cause blisters on the skin.

It may be stated here, that it has not been found possible to replace open-pan method of roasting by roasting in an oven on account of the difficulty of either the nuts remaining tough and leathery at 100°C. or kernels becoming discoloured when heated at a temperature of 120°C. (Joachim, 1936).

2. *Shelling.*—Shelling, which is invariably done by women and some times by boys who are employed on contract system, is carried out in a spacious hall specially erected for the purpose. Shelling is done with a wooden mallet. About 200 women are employed for shelling alone at a contract rate of two pice (half an anna) per pound of whole kernels. A woman working ten hours a day shells 16 to 20 lbs. of kernels, thereby earning eight to ten annas. About 25 to 30 per cent. of kernels are obtained after shelling.

3. *Peeling.*—The kernels after shelling are partially dried in a specially constructed oven to facilitate peeling of the adhering thin skin which is pinkish to reddish brown in colour. Drying of kernels, besides facilitating the removal of the inner coat, removes excess of moisture from them and thus prevents a tendency to mouldiness in storage. The oven consists of five chambers on either side partitioned by a wall with a flue at the bottom. The kernels are filled in long iron mesh trays six feet long and two feet broad which are placed in these chambers where a uniform temperature of 70°C. is maintained. At high temperature, kernels become too brittle and consequently considerable loss due to excessive splitting occurs. This process lasts for six hours when the trays are taken out and skin peeled off carefully. Peeling is done by hand. Peeling can also be effected by spreading the kernels on an open yard fully exposed to the sun. This process, however, is slow occupying nearly two days to effect complete drying. Peeling is entrusted to women and each woman peels from twelve to sixteen lbs. of kernels in a day earning on an average six to eight annas. The yield of kernels after peeling is 80 to 90 per cent.

4. *Sweating.*—The clean kernels are further subjected to an indispensable process of " sweating " to prevent splitting and breaking as only whole kernels are required for export purpose. The " sweating " receptacle consists of six chambers each containing a long rectangular shallow tank of water made of cement. The dimensions of this tank correspond with that of iron mesh trays mentioned above. The trays containing clean kernels are placed over the tank in sweating chambers for the absorption of moisture. The kernels are sweated for a period of two to three hours depending upon the atmospheric conditions and the nature of kernel. When the outside temperature is cold, trays are sweated for three hours and when hot, for two hours only.

5. *Grading.*—Kernels after sweating are graded for the foreign market according to size and quality as follows :—

1st grade	.. .. ..	Sound and big sized kernels.
2nd grade	.. .. ..	Sound and small sized kernels.
3rd grade	.. .. ..	Halves and broken kernels.
4th grade	.. .. ..	Rejects and spoilts.

The first two grades are exported to foreign markets ; the first fetching a much better price than the second. For instance, the first two grades from a factory in Vengurla (Ratnagiri District, Bombay Presidency), fetch Rs. 1,666–10–8 and Rs. 866–10–8 per ton respectively in the American market.

Grading is also done by women who have proved proficient in this process as in shelling and peeling. While grading, diseased and over-baked kernels are sorted out separately to be disposed of locally. The daily earnings of a woman working eight hours a day averages from six to eight annas for grading 55 to 69 lbs. of kernels.

The first grade kernels are white, bold, and hard. Nuts from Travancore (Paul, 1936) yield the best quality kernels while those from the North Kanara are very poor, being hard and fibrous. The yield of kernels from nuts from South Kanara and East Africa is 28 per cent. and 30 per cent. respectively.

6. *Packing.*—Packing of first and second grade kernels for the export trade is effected in tins of 25 lbs. capacity. Some factory owners also use tin-lined wooden boxes with a holding capacity of 112 lbs. of clean kernels. When using the first type of container which is cheaper than the second, packing consists of laying two ounces of oil paper at the bottom over which the above quantity of kernels are put. The top is stuffed with strips of oil paper to avoid breakage by internal movement during transit and finally the cover is hermetically soldered. The container is then exhausted which is effected by making a vent hole in the centre of the cover through which air is removed by means of an air pump. Complete exhaustion is accomplished when the pressure gauge fitted on to the pump indicates 10 lbs. pressure and immediately the vent hole is soldered. Since it is not possible to create a perfect vacuum, some packers charge the kernels with carbon dioxide gas which serves as a preservative. This practice is now discontinued as it is considered objectionable by some importers.

The kernels are now packed by exporters by what is known as the " Vita pack " process which consists of vacuumising the tins automatically and charging them with a compressed carbon dioxide gas by the control of a lever adjustment. Packing kernels by this process is accepted by the continental importers but not by the United States of America owing to the patent which the latter holds. Tins containing kernels for export to the United States of America are simply vacuumised and sealed automatically without being charged with carbon dioxide gas. Even by the latter method, kernels keep well for over two years. The " Vita pack " process can also be successfully adopted in our internal trade.

The nuts could be used in the initial stage in the same way as almonds in confectionary as top layer in cakes and fancy pastries or for chocolate or sugar coating. For successful use of kernels in confectionary in Europe, they have to be further processed before distribution to bakers and confectionary manufacturers. They must be cleaned, polished, and cut in machinery provided for the purpose into various shapes and forms to be utilized for different quality preparations. The forms now common with almonds are (1) wholes, (2) splits or halves, (3) flakes, (5) nibs, and (6) shreds.

It may be pointed out that the grades of cashew kernels imported by the London bakers and confectioners are wholes, splits, and broken tips but unfortunately these do not lend themselves easily for being converted into other required forms. Further, the chief disadvantage of the cashew kernels is that unlike almonds which are devoid of starch, they contain a good amount of it which is indifferently appreciated in the confectionary trade. This drawback is likely to impede the progress of this commodity in Europe and no wonder that it is still practically unknown in most parts over there. This means much up-hill work both for the State and the commercial men but the resources of the former and the patience and enthusiasm of the latter should ultimately overcome all obstacles and achieve the desired object of increasing national wealth through exploitation.

From the facts and figures presented in the foregoing pages, it can be asserted without a shadow of doubt that the cashew-nut industry is an important one

and, therefore, should be developed on sound scientific basis. It is gratifying to note that the cashew kernels are one of the few agricultural products in India which are properly graded and well packed for purposes of export.

The consumption of the cashew-nuts is also steadily increasing in India and it is reported that the South Kanara roasters intend to start a campaign very soon to popularize this commodity in every day use in various centres of this country. As a result of such an admirable move, it is anticipated that the demand for the cashew-nuts for local consumption would be considerably accelerated in the not too distant future. Consequently, an appreciably large quantity of supply of raw nuts would be needed to meet the increased demand. This, therefore, can be achieved by bringing under cultivation more lands specially the *varkas* areas where only the hill millets are at present grown. *Varkas* lands are unsuitable for most of the fruit crops except the cashew-nut and the mango-fruit crops of the same family. Extensive lands are available in the districts of Ratnagiri and Kanara covering an area of 17,000 and 10,000 acres respectively putting it at a very conservative estimate. The area extent is very considerable.

It may be pointed out that 20 lbs. of nuts which the cashew-nut tree yields in its present wild state is not likely to appreciably stimulate its cultivation. It is, however, certainly possible to increase this yield by systematic cultivation, paying due attention to irrigation, manuring, and selection of high-yielding plants.

It would not be appropriate to conclude this part of the subject without alluding to the future prospects of this industry. It may be mentioned with grave concern that with the rapid development of export trade, this industry is maintained by depending upon the supply of raw nuts mostly from countries like British and Portuguese East Africa. The import duty (1937) up to the year 1932 considerably checked large scale import of raw nuts from Portuguese East Africa but with the removal of import duty by Government the same year, the imports of nuts increased from 1,064,000 lbs. in 1931–32 to 29,120,000 lbs. in 1935–36. Now, knowing as they do the potential importance of this commodity, the authorities over there would take immediate steps to undertake to manufacture cashew kernels if the duty is reimposed. This threatening foreign competition is likely to paralyse the prosperity of our national industry. Under the circumstances, this industry which employs something like 100,000 workers throughout the year would be thrown out of employment for at least half the year as the factories would work on only the available local supply from the coast ports of India. This danger can be averted by imposing a light import duty or any other feasible measure.

(*b*) THE CASHEW APPLE

The cashew-nut owners, before the Abkari Act was passed, used to distil an agreeable liquor from the cashew apple and used it for diuretic purposes. Locally the ripe fruits are eaten mixed with salt or the juice is extracted and fermented with sugar for the preparation of vinegar. Until as recently as this year, liquor was not distilled anywhere in the British territory of South India except in the Portuguese territory and the Sawantwadi State.

The suitability of the cashew apple in the distillation of liquor can be ascertained at a glance from the composition (1922) of the cashew apple juice mentioned below :—

	Per cent.
Acidity in grammes of sulphuric acid	0·28
Reducing sugar	11·96
Non-reducing sugar	0·66
Total sugars	12·62

Besides, the juice is rich in pectin contents.

DISTILLATION OF LIQUOR FROM THE CASHEW APPLE

To extract juice, ripe apples (Sayed, 1931) are crushed under feet in wooden vessels or stone vats which give nearly 62 per cent. extraction. The juice is strained through a coarse cloth to remove foreign matter and coarse material and stored in large copper vessels for fermentation for seven days. The fermented juice is poured in another copper vessel of forty gallons capacity. A pipe four inches in diameter is soldered to this vessel which communicates with another brass vessel. The first one is mounted on a low circular furnace made of earth which is fed by the dry cashew-nut leaves. As the juice is heated, the vapours travel through the communicating pipe and are liquified in the second vessel by pouring cold water over it. This operation is carried out by two men. The distillation process is discontinued when the distilled liquor is one-third the capacity of the first vessel. This is ascertained merely by tapping the vessel which is a matter of experience. The distilled liquor is then poured into earthen vessels and is allowed to stand for twenty-four hours when it is finally stored in stock barrels of capacities ranging from 268 to 619 gallons. Forty gallons of apple juice yield eight gallons of distilled liquor. The distilled liquor is perfectly clear like water. Distillers sometimes purchase apple juice from outside at the rate varying from two and half to three annas for four gallons. The liquor is sold at Re. 1-8-0 per gallon.

The cashew liquor is manufactured in the Sawantwadi State, Goa, and Malwan (Ratnagiri District). The quantity of cashew liquor manufactured in Goa is as follows :—

Year.	20 per cent. water Gallons	25 per cent. water Gallons	60 per cent. water Gallons
1930 ..	448 ..	8,560 ..	163,309
1931 ..	269 ..	10,358 ..	163,230
1932 ..	188 ..	8,935 ..	138,145

It is surprising that this industry has not received its due encouragement which it deserves although, as it is obvious, it would have been an additional source of revenue to the State. As said elsewhere, the distillation of liquor is restricted to a few remote localities. Therefore, as a measure of experiment, the State may start one or two distilleries in the South Kanara Districts to ascertain how far cashew liquor can be economically prepared or else, only a few prospective distillers may be permitted to manufacture this liquor. It is believed that the cashew liquor will have a popular demand from the local people on account of its recognized medicinal properties and because it would be available very cheap.

(c) PERICARP OIL

The hard shells of the cashew-nut yield oil which on exposure turns black quickly and is known as cashew oil, cardoil, or cardol. This oil is considered to be a corrosive poison like crude carbolic acid and is required to be used with caution. The chief constituents of the pericarp oil are anacardic acid, gallic acid, and cardol (Joachim, 1936). The oil is reddish brown in colour.

The production of the cashew-nut oil has increased appreciably in recent years owing to large scale export of cashew kernels to the United States of America and other European countries. It is estimated (Patel and Patel, 1936) that about 71,480,000 lbs. of raw nuts are annually decorticated in India. The quantity of shells available for extraction is 29,120,000 lbs. which would yield 53,000 gallons of oil.

The shells of the nut by the present manufacturing process yield only 12 to 15 per cent. oil although they contain 35 per cent. oil. A bottle of cashew oil fetches one and a half anna or Re. 1–4–0 a gallon.

The oil is largely used by fishermen to tan their nets. It is also effectively utilized in preventing white ants attack when painted on furniture, stationery, &c. The oil has also been recommended as an external application for leprosy as it is considered to be a specific remedy for it and also for ringworms and corns.

OTHER USES OF THE CASHEW-NUT TREE

1. Locally green cashew-nuts are cut open with a knife and the unripe kernels are used either as spiced vegetables or boiled with sugar syrup to make a sweet dish. The green kernels do not keep long and like green vegetables have to be used rapidly.

2. The unpeeled cashew kernels form a good poultry food. The nutritive value of the kernels is also high as can be seen from the following analyses (Joachim, 1936).

	Per cent.
Water	8·1
Protein	7·6
Fat	12·3
Carbohydrates	59·2
Fibre	11·0
Ash	1·8

The kernels make a good candy when mixed with cocoa.

3. The tree yields a gum and the chief characteristic feature of it is that it possesses insecticidal properties and helps to ward off the attacks of insects. The gum is soluble in water and is often used in book binding in this country.

The tree also yields a useful timber which is commonly utilized in boat making and occasionally for making packing cases. It can be converted into charcoal.

4. The cashew leaves serve the double purpose of tooth powder and tooth brush and the users, it is said, retain their teeth to a ripe old age ; the acid contained in the leaves acting as the toning agent of the gums. The bark is used in the preparation of effective mouth wash and the root is used as a purgative.

5. The kernels contain 40 to 50 per cent. oil which is light yellow in colour and sweet in taste. It is non-drying and can be used as food oil, provided it is carefully prepared. The residual cake after the oil is expressed is rich in albuminoids (Ludowyk, 1927).

6. The apple juice is rich in pectin and can be utilized in the preparation of preserves. The fruit is juicy and contains 65 per cent. juice of the weight of fruit. This juice when mixed with iron sulphate makes an excellent hair dye (Galang & Lazo, 1936).

SUMMARY AND SUGGESTIONS

The importance of the cashew-nut industry as an Empire product needs no emphasis as the export figures as well as growing internal demand bear testimony to its justification. That the cashew-nut forms a very suitable and cheaper substitute for almond in confectionary and bakery trades is so well recognized by the United States of America that it made rapid strides in exploiting the import of this commodity and is now importing annually enormous quantities of the shelled nuts and clean kernels. Further, its demand is steadily increasing on the continent and in India.

The utilization of the cashew apple in the distillation of an agreeable liquor which is so much esteemed by the local people gives an indication that three people, *viz.*, the grower, the distiller, and the State are going to be considerably benefitted by this industry. This would mean total prevention of loss of ripe fruits which now occurs in large quantities. The future of this industry, therefore, rests entirely with the industrialist and the State. The instance of the Portuguese Government manufacturing liquor from the cashew apple from which they derive a rich revenue should infuse sufficient interest among the industrialist and the State to promote this indigenous industry at a very early date.

It may be concluded with modest optimism from the survey of facts and figures set down in these pages that the cashew-nut industry and the industries subsidiary to it have got a bright future and with proper exploitation through publicity and propaganda both by the State and those of the public interested in it, they would constitute a great advance in the promotion of the indigenous industry and consequently augment national wealth. In this connection the following suggestions are offered which it is believed would be of material use in the exploitation and advancement of the cashew-nut industry :—

1. Immediate measures may be adopted to exploit the market of our Empire product as a source of national wealth by allotting a special grant for publicity and propaganda.

2. Attempts may be made to evolve mechanical devices for roasting, shelling, &c., so as to overcome foreign competition.

3. To meet the increasing foreign and local demand, more lands may be brought under cultivation with a view to lessen the import of raw nuts from foreign countries and scientific methods of cultivation adopted to increase the yield of the cashew-nut trees.

The cultivation of the trees is not very difficult and, therefore, it will be easy for the Agricultural Department to achieve this object by intensive propaganda. It is, however, not possible for the Forest Department to undertake the cashew-nut tree plantations on a large scale as the main object of that Department is to plant timber-yielding species.

4. The cultivation of the cashew-nut tree may be extended and popularized by educating the private owners of *varkas* lands to its importance and value in the field of trade and impressing upon them the evils of indiscriminate felling of these trees for the purpose of fuel.

5. The State may consider the advisability of disposing *varkas* lands to persons interested in the cultivation of cashew-nuts on easy terms of payment to enable large plantations being established for promoting its cultivation as a money crop.

6. The industrial and economic interest of the grower and manufacturer should be safeguarded from foreign competition by appropriate legislative measures. This object can also be achieved by encouraging the establishment of a few more factories with a view to minimise import of raw nuts and thus accelerate export trade.

7. It would be desirable if the Provincial Governments negotiate with the railway and shipping companies and urge the necessity of reducing freights on cashew-nuts.

8. Investigations with regard to transporting, drying, and storage of cashew apples may be undertaken. Production of alcohol from dried apples also needs thorough investigation.

9. If at present Government do not consider it feasible to start distilleries, permission may be granted to a few private individuals to do so and the excise duty charged on the output which would mean an additional revenue to the State.

SOIL NUTRITION*

WE venture to suggest that a new branch of soil science be recognized, namely, soil nutrition. Soil nutrition would be related to general pedology in much the same way as plant nutrition is to botany or animal nutrition to zoology. At present we speak of supplying nutrients to the soil when we mean supplying nutrients to the plants that grow on the soil. A clearer distinction could be made between soil nutrition and plant nutrition—a distinction which might relieve the soil chemist from spending so much of his time on what is essentially the plant physiologist's job and enable him to pay closer attention to the soil.

It must be emphasized that the term nutrition, as applied to the soil, is used in an analogous sense to plant and animal nutrition, for want of a better word. A properly fed plant is in a condition to manufacture animal foods in which plant nutrients play a quantitatively subordinate part. By analogy, a properly fed soil is one which is in a condition to manufacture plant nutrients in a form in which they are available for plant growth. Most soils possess an almost limitless supply of the major and minor plant nutrients (and toxins) and, when properly nourished, give them up to, or withhold them from, the vegetation in the quantities required for normal plant growth. The mechanism of this remarkable process should be the subject of the soil nutrionist's study. Soil nutrition may not be of much practical importance in agriculture, where plant nutrition is becoming increasingly independent of the soil, but it is fundamental to the science of the soil. Agriculture tends to regard soil as a somewhat inefficient substitute for sand or water as a medium for conveying nutrients to the plant, but where the hand of man is absent plant growth depends primarily upon the processes of soil nutrition, as much as the welfare of the animal world depends ultimately upon plant nutrition. Soil nutrition may thus be regarded as a fundamental process in the cycle of life and worthy of the closest scientific study apart from any practical advantages that might accrue from such study.

The study might start by a consideration of soils showing obvious symptoms of malnutrition. Malnutrition is not necessarily indicated when a soil responds readily to ordinary manurial dressings, since such response may be due merely to the abnormal demands of a heavy crop being met by the applied nutrients, and may have nothing to do with the ability of the soil to render its own supply of plant nutrients available. Malnutrition shows itself rather when some physical or chemical treatment produces an increase in vegetal production out of all proportion to the amount of plant nutrients—if any—applied. Such a disproportionate increase implies that the production of available nutrients *by the soil* has been stimulated by treatment.

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* Reproduced from *Soils and Fertilizers*, vol. I., No. 5, 1938, pages 181–183, issued by the Imperial Bureau of Soil Science.

Simple cases of feeding ill-nourished soils are exemplified by drainage and cultivations which, *per se*, produce increased yields. The ways in which such operations feed the soil are believed to be known, but there are certain other cases of malnutrition which the soil chemist finds difficulty in explaining according to orthodox plant-nutrition theory. Some of these cases are capable of quite simple explanation, others demand the exercise of imagination. A few examples may be given.

Cultivated crops in the tropics sometimes respond readily to organic manures where artificials are without effect. It has been suggested that the readily available artificials " burn " the crops, while the organically combined nutrients are released more gradually. A particular case is illustrated by the remarkable response obtained to small dressings of farmyard manure (2 tons per acre) in Nigeria, where complete artificial-fertilizer treatment was ineffective. The extra nutrient uptake in the manured plants was greater than the amount supplied by the manure. Later work has shown that much the same response is obtained by applying superphosphate in the absence of nitrogen and potash.

Large yield increases have also been obtained in South Russia by applying enormous quantities of superphosphate to lateritic soils, although there was little or no recovery of added phosphate in the crop. Here the phosphate may act by precipitating toxic aluminium in the soil.

A somewhat analogous abnormal response to phosphate has frequently been observed in young conifer plantations on acid peats where growth may be 5–10 times as vigorous on slagged plots as on controls. Under these conditions other artificial fertilizers (including superphosphates) are without effect or are deleterious.

M. C. Rayner has obtained remarkable results by using specially prepared composts, poor in nutrients, with conifer seedlings on strongly podzolized soils. The treated plants throve better than similar plants grown in fertile nursery soil, whereas the controls failed entirely. The composts, moreover, had no effect except when applied to very poor soils, in fact they sometimes depressed growth on good soils. There can be no doubt but that something other than a direct plant-nutrient effect is involved here. Dr. Rayner attributes her results partly to a stimulation of the mycorrhizal habit in the trees by the composts and, more generally, to a " change of direction of the biological activities responsible for humus decomposition ". The origin of the compost material has a very marked influence on the efficacy of the product. Basic slag on these mineral soils has also a considerable effect which is not readily explained on the same grounds as the compost effect.

Dhar, in India, has made alkaline soils productive by applying molasses, poor in plant nutrients. The decomposition products of the molasses presumably neutralize soil alkalinity besides stimulating micro-biological activity.

In all these cases plants on the treated or " fed " soils took up more nutrients in comparison with the controls, than could be accounted for in the nutrients applied, that is, the soil was put into a condition where it could feed the plants from its own reserves. This is a soil's natural and primary function. When it performs that function it is healthy ; when it is merely a temporary receptacle

for added plant nutrients and cannot itself feed a crop it is unhealthy, even though it may yield a profit to fertilizing. The medical profession has latterly decided that the study of health— if time can be found for it— is just as important as getting sick people back to a workable condition, and the pedological profession—if it could find time—might equally pay attention to discovering what a soil requires for normal functioning as well as to making fertilizers give their maximum return when applied to the soil.

Numerous facts are already available with regard to soil health but they have been considered more in relation to their bearing on plant than on soil nutrition. The physico-chemical condition of the soil is obviously of first importance, and possibly the main function of soil nutrients is to maintain a regulated series of precipitation and solution reactions in the soil mass. There is nothing very novel about the concept of soil nutrition ; the advantage of treating it as a distinct branch of pedology would be that, apart from drawing the pedologist's attention to the soil, it might bring into their proper relationship such apparently diverse phenomena as the failures of pine transplants on acid heaths and of farm crops in the topics. They may have the same kind of relationship to one another as two such dissimilar phenomena as, *e.g.*, potash-deficiency symptoms in bananas and in sugar-beet. Certain effects of minor elements in the soil may admit of more plausible explanation as soil-nutrition than as plant nutrition phenomena.

The examples of soil malnutrition cited above suggest that phosphate may be just as important a soil nutrient as it is a plant nutrient, and that the phosphate requirement of a soil may have a more literal meaning than that usually given to it. Lime requirement is certainly more a soil-nutrition than a plant-nutrition term. Nitrogen is obviously a soil nutrient, but in organic combination and not as ammonium or nitrate. We cannot think of any evidence that potash is an essential soil nutrient. The claims of other commonly occurring constituents such as silica, iron and aluminium as soil nutrients deserve consideration. Humus may—almost certainly does—contain soil nutrients other than nitrogen and phosphorus, but what these are and how they function is unknown. A knowledge of the basic principles of soil nutrition should go far towards elucidating the chemistry of humus. It should also enable us to correlate the working of the various " cycles "—of weathering, organic matter, vegetation, micro-organisms, &c.—and to obtain a clearer picture of the intricate internal mechanism of soil.

THE SETTLEMENT OF EDUCATED MEN ON THE LAND*

IN his "Report on the Work of the Imperial Council of Agricultural Research in Applying Science to Crop Production in India", Sir John Russell has referred to the great gap which exists between what could be accomplished by the cultivator in India if he were to utilize fully the knowledge available as a result of agricultural research and what is actually being done by him. For instance, by adopting better methods of cultivation, using improved varieties of seed and protecting their crops from the ravages of diseases and pests, agricultural experimental stations obtain, in the case of most crops, yields vastly greater than those obtained by the average cultivator. But, although such advantages can be gained by utilizing present knowledge, the cultivator still continues largely to follow his old methods and adopts the achievements of research only to a limited extent. The great need, therefore, of the present time is to take adequate steps to ensure their wider and fuller adoption.

Sir John considers that one of the greatest handicaps under which Indian agriculture labours in this connection is the absence of an educated agricultural middle class in the village and he contrasts the position here with that in Western countries where he attributes many of the great advances, which have been made, to the shrewdness, and progressive ideas of men of this type. In view of this conclusion, it will be of interest to consider some practical steps which are being taken at present in India to settle educated young men on the land.

Efforts have been made on a small scale in recent years in Mysore and Travancore to place on the land young men who had first obtained some training at an agricultural school. In the former case, progress appears to be slow so far, whilst in the latter, twenty-four trained boys have been placed on holdings of ten acres each. It is a condition of tenancy that students must live on the land and farm it under the guidance and supervision of officers of the Agricultural Department. A loan up to Rs. 500 is also granted to the student tenant, where required, for the purchase of seeds, manure, implements, &c., and after repayment in full, if all the conditions of the lease have been observed satisfactorily, the land is permanently assigned to him.

By far the largest experiment so far made in placing educated men on the land, is being carried out in the Punjab, where an experimental scheme was started in 1932. In that year, two villages situated in one of the canal irrigated tracts were colonized entirely by forty-eight educated youths, consisting of forty-four graduates and under-graduates of Arts and Science colleges and

* Editorial article in *Agriculture and Livestock in India*, Vol. VIII., Part VI., November, 1938.

four graduates in Agriculture. Each grantee was allotted two squares (fifty-five acres) of canal irrigated land. The principal conditions attached to the lease are :—

(1) The tenant must live permanently on the land and must build on it a residential house to the satisfaction of the local Collector,

(2) The tenant must cultivate the whole of his land with his own hands but he is allowed to employ paid labour to assist him in doing so,

(3) After the expiration of five years, if all the conditions have been observed satisfactorily, the tenant is granted occupancy rights, but he does not obtain proprietory rights,

(4) The tenancies are subject to the rule of primogeniture, but if a tenant dies without having acquired occupancy rights, the tenancy lapses to Government.

During the first two harvests after the commencement of the tenancy Government remitted the whole demand on account of land revenue, *malikana*, occupiers rates and cesses.

In the same year (1932) a considerable number of Agricultural Assistants, many of them possessing some years' experience of departmental work, was brought under reduction, due to financial stringency, and the Punjab Government allotted them similar grants on similar conditions. In this case, however, the grantees were not located in villages set apart for themselves but were scattered in pairs in old colonized villages, where it is expected that by the adoption of the modern methods of farming which they had learnt and which they had been demonstrating to cultivators previously, they will serve as examples for the ordinary cultivators surrounding them of what could be achieved by farming on modern lines.

Again, in 1937, two more villages in canal irrigated areas were completely colonized by forty-one more literate grantees. They consisted of eleven graduates and certificate holders in Agriculture and thirty graduates or undergraduates from Arts and Science colleges. Finally, in the same year also, thirty-eight graduates and certificate holders in Agriculture were allotted similar grants and, as in the case of the retrenched Agricultural Assistants, were scattered in pairs throughout the older villages.

At present, therefore, 8,910 acres of land in the Punjab have been colonized by 162 educated young men, of whom eighty-nine are the sole cultivators in four villages and the remainder are scattered, usually in pairs, in the older villages. The experiment must continue further before any final conclusions can be reached as to its success or otherwise. A recent visit to some of the grants, however, indicated that ultimate success or failure is likely to depend very greatly on the individuals concerned. There is no doubt whatever that those lessees, who have had an agricultural education, are in a much better position to make a success of their grants than those from Arts and Science colleges and yet some men of the latter class, who have had the foresight to copy the methods employed by their agriculturally trained co-villagers, are producing results which compare very favourably with those of the latter. Even amongst themselves the agriculturally trained graduates vary in their

achievements, depending on the extent to which they are prepared to work and to apply the training which they have received. Some of them have been outstandingly successful and in some cases they have actually obtained yields of wheat and cotton which are almost a record and which compare very favourably with the best results which have so far been obtained on agricultural experimental stations in the province.

The further progress of this experiment will be watched with considerable interest not only in the Punjab itself but throughout India.

MEETINGS, CONFERENCES, &c.

RUBBER RESEARCH SCHEME (CEYLON)

DRAFT MINUTES OF THE FORTY-SIXTH MEETING OF THE RUBBER RESEARCH BOARD HELD IN THE COMMITTEE ROOM OF THE CEYLON CHAMBER OF COMMERCE, COLOMBO, AT 2.30 P.M. ON TUESDAY, JANUARY 17, 1939

Present.—Mr. F. P. Jepson, Acting Director of Agriculture (in the chair); Mr. C. H. Collins, C.C.S. (Deputy Financial Secretary); Mr. I. L. Cameron; Mr. L. M. M. Dias; Mr. L. B. de Mel, J.P., U.P.M.; Mr. G. E. de Silva, M.S.C.; Mr. L. P. Gapp; Mr. F. H. Griffith, M.S.C.; Col. T. G. Jayewardene, V.D.; Mr. R. C. Kannangara, M.S.C.; Mr. J. C. Kelly; Mr. F. A. Obeyesekere; Mr. J. L. D. Peiris; Mr. B. M. Selwyn; Mr. E. W. Whitelaw.

Mr. T. E. H. O'Brien, Director, was present by invitation.

Before proceeding with the agenda the Chairman said he wished to report that he had assumed duties as Chairman of the Board with effect from December 1, 1938, while acting as Director of Agriculture in the absence of Mr. E. Rodrigo, who was on leave. Mr. Rodrigo was expected to resume duties on March 1, 1939.

Reported that messages of good wishes for 1939 had been received from the Rubber Growers' Association, the Rubber Research Institute of Malaya, and the Ceylon Association in London.

1. Minutes.—

Draft minutes of the forty-fifth meeting which had been circulated to members were confirmed and signed by the Chairman.

2. Board.—

Reported the following changes in the membership of the Board since the last meeting :—

(1) Mr. E. W. Whitelaw's three year period of office had expired on December 14, 1938, and he had been re-nominated by the Rubber Growers' Association to serve for a further period of three years from that date.

(2) Mr. R. P. Gaddum had resigned with effect from January 10, 1939.

(3) Mr. J. C. Kelly had resumed membership on return to the island with effect from December 6, 1938, relieving Mr. R. A. Sharrocks, who had acted for him.

Votes of thanks were passed for the services of Messrs. Gaddum and Sharrocks.

3. Accounts.—

(*a*) *Statement of Receipts and Payments of the Board* for the quarter ended September 30, 1938 (C.P. 727) was approved.

(*b*) *Dartonfield and Nivitigalakele accounts* for July, August, September and October, 1938, were tabled.

(*c*) *Depreciation rates.*—Reported that, as decided at the last meeting, the advice of the Treasury representative had been sought regarding amendment of the allowances to be made for depreciation of fixed assets. After consideration of the recommendations made by the Treasury representative the following rates were approved :—

	New Rate.	Old Rate.
Buildings ..	.. 3½%	.. 4 %
Plant and Machinery ..	.. 7½%	.. 7½%
Lab. Equipment ..	.. 7½%	.. 25 %
Electric accumulators ..	.. 20 %	.. 7½%

(*d*) *Fixed deposit.*—Reported that a fixed deposit of Rs. 50,000 had been renewed for a further period of 12 months from December 31, 1938.

(*e*) *Investment of Funds.*—The following Committee was appointed to consider the question of future investment of funds and report to the Board :—

The Chairman of the Board, The Treasury representative, Mr. J. C. Kelly, and Col. T. G. Jayewardene, V.D.

(*f*) *Employees' Provident Fund.*—Consideration was given to a proposal to modify the rules of the employees' provident fund so that all monthly paid employees would become eligible for membership. After discussion it was decided to refer the matter to the Committee appointed to consider the investment of funds.

4. Staff.—

(*a*) Reported that Dr. L. A. Whelan, M.Sc. (N. Z.), Ph.D. (Aberdeen), A.I.C., the newly appointed Soil Chemist, had arrived in Ceylon on October 31, 1938.

(*b*) Reported that Mr. M. W. Philpott, Chemist, had returned from leave on November 14.

(*c*) Reported that Mr. P. Tharmalingam, B.Sc., had been appointed Analyst in the Soils Department with effect from January 3, 1939, in accordance with the decision reached by circulation of papers.

5. Experimental Committee.—

Recommendations made at a meeting held on December 19, 1938.

(*a*) *Over-expenditure of votes.*—Supplementary votes of Rs. 87 and Rs. 40 were approved to meet over-expenditure in replanted areas No. 2*a* and 3, at Dartonfield Estate.

(*b*) *Training in estate works.*—Arising from an application for training in general field works consideration was given to the possibility of facilities being given for such training at Dartonfield and Nivitigalakele. After discussoin the Director was asked to submit proposals to the Experimental Committee for consideration.

(*c*) *Identification of clones.*—Reported that the Chinese Mandor, who had been engaged in the identification of clones on estates, would return to Malaya on February 9. It was agreed that the services of Research Scheme officers should be made available for this work in future, subject to their travelling expenses being refunded by the estates concerned.

6. **Technical Officers Progress Reports for the Quarter ended September 30, 1938,** were adopted without comment.—

A copy of notes prepared by Mr. Philpott dealing with visits to factories, &c., and interviews while on leave in England was tabled. It was agreed that one copy of the notes be circulated to members.

7. **London Advisory Committee.**—

Minutes of meetings of the London Advisory Committee for Rubber Research (Ceylon and Malaya) and the Technical Sub-Committee held on September 30 and October 14, 1938, respectively were adopted.

8. **New Rubber Planting.**—

Reported that Government had adopted a scheme for giving advice and assistance to persons of the middle and peasant classes in the planting of Rubber under the terms of the Rubber New Planting Ordinance, No. 38 of 1938. An officer of the Department of Agriculture had been seconded for duties as Chief Advisory Officer in the Land Commissioner's Department and would have a staff of about 50 instructors.

As part of the arrangements, the Research Scheme had been requested to prepare a manual of instruction in new planting. The work had been undertaken by Mr. R. K. S. Murray, who had completed the draft of part I. dealing with first year planting operations.

It was also desired by Government that the instructors should be trained at Nivitigalakele. The time available was very short and it was proposed that the instructors should be taken in four batches for a period of 2 weeks training in contour lining, cutting of drains, &c. The Smallholdings Propaganda Officer would be in charge of the work. The proposal was approved.

9. **Rubber Conferences.**—

Reported that the Rubber Conference held at Tebuwana, on November 25, 1938, under the auspices of the Planters' Association of Ceylon and with the co-operation of the Research Scheme, had been very successful. It was agreed that future Conferences should be organized on similar lines and that the Research Scheme would co-operate fully with the Planters' Association in the matter.

The meeting terminated with a vote of thanks to the Chamber of Commerce for the use of the Committee Room.

Research Laboratories,
Dartonfield,
Agalawatta.

February 2, 1939.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD IN THE COMMITTEE ROOM OF THE CEYLON CHAMBER OF COMMERCE ON THURSDAY, DECEMBER 22, 1938, AT 2.30 P.M.

Present—Mr. James Forbes, Jnr. (Chairman); The Hon. the Financial Secretary (Mr. H. J. Huxham); The Acting Director of Agriculture (Mr. F. P. Jepson); The Chairman, Planters' Association of Ceylon (Mr. R. C. Scott); The Chairman, Ceylon Estates Proprietary Association (Mr. R. J. Hartley); Major J. W. Oldfield, C.M.G., O.B.E., M.C.; Mr. I. L. Cameron; Mr. J. D. Hoare; Mr. J. C. Kelly; Mr. T. B. Panabokke, and Dr. R. V. Norris (Director and Secretary). Messrs. H. Tonks (Visiting Agent) and J. A. Rogers (Superintendent) were present by invitation.

Absent.—Mr. R. G. Coombe and Mr. S. F. H. Perera.

1. The Notice convening the meeting was read.

A letter was tabled from Mr. R. G. Coombe, expressing regret at inability to attend.

2. The Minutes of the Meeting of the Board held on October 28, 1938, were confirmed.

3. Membership of the Board and Committees.—

Reported that Mr. J. C. Kelly, had resumed his seat on the Board on his return from leave, relieving Mr. K. W. Taylor.

A vote of thanks to Mr. Taylor for his services was recorded.

The Chairman welcomed Mr. F. P. Jepson, who was acting Director of Agriculture in place of Mr. E. Rodrigo, who had gone on leave.

4. Finance.—

(*a*) The Institute's Accounts to November 30, 1938, were approved without comment.

(*b*) *Adjustments of Votes.*—Various adjustments of sub-votes sanctioned by the Chairman under Rule 19(*e*) were confirmed by the Board.

The following additional votes were approved:—

Research Revenue Account.—

General Services.—Vote 57, Water Supply Rs. 350.
Miscellaneous.—Vote 71, Medical Scheme Junior Staff, Rs. 70.
Vote 72, Medical Fees Sub-staff, Rs. 140.

Estate Working Account.—

Vote 63, Machinery upkeep, Rs. 275.
Vote 22, Watchers, Rs. 175.

(*c*) *Investments.*—Reported that the Seal of the Board had been affixed to the transfer certificates and Interest notices relating to the recent purchase of 4 per cent. Funding Loan as sanctioned by the Board at the last meeting.

(*d*) *T.R.I. Cess.*—Reported that the Ordinance to provide for the continuance of the Cess at 14 cents per 100 lb. tea exported until December 31, 1943, was passed by the State Council without division on December 14, 1939.

The Chairman expressed his indebtedness to the Financial Secretary, Major Oldfield and Mr. Gaddum for their assistance in this matter.

(*e*) *Estimates 1939.*—The Chairman said these had been circulated to the Board and had been before the Finance Sub-Committee that morning.

A. *Working Account.*

It was noted that the estimates were based on a crop of 185,000 lb. a check roll average of 54 cents, and a plucking average of 45 cents.

The Board approved that General Charges be divided between Working Account and Capital in the proportion of $83\frac{1}{2}$ per cent. to Working Account and $16\frac{1}{2}$ per cent. to Capital.

The Board then approved the estimate for estate working account amounting to Rs. 93,870 or 50·75 cents per pound.

B. *Estate Capital Account.*

In reply to the Financial Secretary who referred to the cost of bringing immature areas into bearing, the Chairman explained that the proportion of General Charges debitable to Capital would be reduced in the following year. Figures would then be prepared giving the cost of clearings.

The Estimate for Estate Capital Expenditure amounting to Rs. 15,371 was approved.

Research Revenue Expenditure.—It was noted that provision was made under Votes 2 and 39 for the Chairman and Director to visit N. E. India and the Tocklai Experimental Station during the year.

The Board approved the estimate of Rs. 240,528 under Research Revenue Account.

The Board approved the revised estimate of Rs. 15,875 under Research Capital Account.

The Board also sanctioned the carrying forward to 1939 account of any unexpended balance of the votes for the Guest House and Equipment.

5. St. Coombs Estate.—

The Chairman said the Visiting Agent's Report for December had only just been received and would come before the Board at the next meeting after consideration by the Experimental Committee.

6. Rules for Guest House.—

The Board considered the draft rules for the use of the Guest House as recommended by the Finance Committee. After minor modifications in wording, the Board approved these rules with the addition of a rule relating to recoveries for breakages.

In reply to Mr. Hoare, the Chairman said a Guest House account would be maintained.

He also informed the Board that the Guest House should be ready for occupation in February.

7. T. R. I. Conference.—

The Board approved the date of the Conference being changed to February 13 and 14 to enable Sir John Russell, F.R.S., to attend.

It was also agreed to hold the meeting on the 13th at the D.A. and C.C., Radella.

The draft programme for the Conference was approved.

8. Research on Chemistry of Tea.—

The Director reported that information had been received from the Ceylon Association in London that the N.E.I. Authorities had agreed to contribute to the Joint Research Fund for 5 years. It was hoped a contribution would also be obtained from the South Indian Tea Association.

Mr. Lamb was in touch with Dr. Lampitt in regard to the technical aspects of the scheme.

9. Any other Business.—

(i.) The Board approved of the Director accepting an invitation to broadcast to Schools on March 9, on the work of the Institute.

(ii.) A vote of thanks was accorded to the Ceylon Chamber of Commerce for the use of their room for meetings of the Board.

The Meeting then terminated with a vote of thanks to the Chair.

ROLAND V. NORRIS,
Secretary.

January 6, 1939.

REVIEW

International Bibliography of Agricultural Economics.—A new quarterly publication of the International Institute of Agriculture in Rome. Subscription 6*s*. 6*d*. per annum.

THE International Institute of Agriculture in Rome has now begun to publish a current bibliography, at quarterly intervals, which deals with agricultural economics in all its various phases. This bibliography, which is based on the material received by the Library of the Institute, is compiled under the technical direction of the Librarian, Dr. S. von Frauendorfer.

The International Bibliography of Agricultural Economics covers the economic and social aspects of agriculture, such as agricultural economics, agricultural policy, settlement, credit, co-operation, insurance, marketing, prices, statistics, farm organization and management, valuation, labour, accounting, rural sociology, agricultural history and geography, legislation and education and all other agricultural problems, in so far as they are considered from the economic and social point of view. Only publications of purely technical character are excluded. Titles of all publications, whether books, bulletins, pamphlets or articles in periodicals, are indicated, including all bibliographical details required for proper identification. All languages receive equal treatment and titles in the less known languages are provided with a translation.

The bibliography, which is the only one which covers systematically the world literature on agricultural economics, is carefully classified by subjects. An author-index will be supplied at the end of each volume. The annual subscription, postage included, is 6*s*. 6*d*. or $1,60.

Les Sols de l'Afrique Centrale, Specialement du Congo Belge.—The Soils of Central Africa, especially of the Belgian Congo. Volume I, The Lower Congo. By J. Baeyens. Publications of the National Institute for the Agronomic Study of the Belgian Congo, 1938. Price 150 Fr.

THIS great work by Prof. Baeyens on the Soils of the Lower Congo is the first of a series on the soils of Central Africa, particularly of the Belgian Congo. As a treatise on the soils of a particular tropical region, it will rank with, if not excel, that of Mohr's *Tropical Soil Forming Processes in Java and Sumatra.* It is therefore not surprising that the book has won for the author the much coveted Barman Prize, awarded in Belgium for the best work of the year on any subject connected with scientific research in the Colonies. It is written in French but contains summaries in English and German at the end of each chapter.

Sir John Russell, the Director of Rothamsted Station, in a preface to the book comments on it thus : " Not only has he (the author) presented, in regard to the knowledge of these soils, points of view which merit the gratitude of his colleagues in all tropical countries of the world, but he has been able to establish a fertility scale based on analytical data which will be useful to planters and to officers charged with finding new possibilities for tropical crops."

The book is divided into two parts. The first deals with the general pedological properties of the soils of the Lower Congo consisting of nine chapters on such subjects as " factors of fertility", " importance of the profile study", " mechanical properties and the structure", " chemical and colloidal properties", &c., of the soils of the Lower Congo. In the second section of the book, the soils are examined from the standpoint of their natural agricultural properties, and classified on a pedological scale of fertility in respect of the different tropical crops of major importance grown in the Lower Congo. The nine chapters which constitute this section deal with principles applied in the construction of a pedological scale of fertility for the soils of Lower Congo, sugar, cacao, coffee, rubber and oil palm plantations, pedological characteristics and agricultural value of the soils of Lower Congo and examples of pedological studies of certain virgin soils with a view to determining probable fertility. This part of the book is extremely helpful to soil workers in tropical countries who, like the reviewer, are entrusted with the responsible task of surveying the crop suitabilities of undeveloped areas in their respective countries, often under disadvantageous and difficult conditions. The book will repay the careful study of every tropical soil worker as it furnishes numerous examples of the practical application of the results of modern field and laboratory soil studies to tropical crops.

The book is profusely illustrated with photographs, diagrams and maps, is replete with tables, both in the text and appendices, and contains an extremely comprehensive bibliography of books and publications relating to the subjects discussed.

No research institution, in the tropics particularly, can afford to be without this book which, while it may not deal specifically with all the important tropical crops, opens up new vistas for profitable soil research and investigation in these regions of the world.—A. W. R. J.

Plant Injection for Diagnostic and Curative Purposes.—By W. A. Roach. Imperial Bureau of Horticulture and Plantation Crops. Technical Communication No. 10. 5*s*.

DR. Roach, in publishing his monograph on plant injection methods for diagnostic and curative purposes, has placed the horticulturist, the plant physiologist, the plant biochemist, and all those interested in the subject of deficiency diseases under a debt of gratitude to him, for he has brought order out of chaos in a field of work which, undertaken on correct lines, offers great academic and economic possibilities. In this publication, the author first traces the history of plant injection from the earliest times to the present day, indicating, in particular, the results of recent investigations on the subject. He then details the different injection methods devised by him, and the results achieved by their adoption on material ranging from the leaf of a strawberry plant to fully grown orchard trees such as apples and plums with such clarity and detail that even the inexperienced experimenter cannot fail to avoid the numerous pitfalls which would otherwise beset his path. The usefulness of the section on injection methods is enchanced by the inclusion of certain methods of other workers, *e.g.*, Leach's shoot injection method. Solid injection is not dealt with in any detail.

In his general discussion of the application of plant injection methods and throughout the monograph, Dr. Roach quotes a number of instances where the adoption of these methods has proved of considerable value. Among these are the diagnosis of an iron chlorosis in fruit trees at East Malling ; the determination of the cause and cure of a disease of apples in Canada and New Zealand as a result of boron deficiency and of a dieback in apple trees in South Australia due to copper deficiency ; the tracing of the cause of a chlorosis of tea in East Africa to a deficient sulphur reserve in the soil ; the increase in vigour and freedom from attack by insects of injected apple trees and the control of silver leaf disease by the injection of nutrient salts or other substances in England.

In a foreword to the communication, Prof. V. H. Blackman of the Research Institute of Plant Physiology, Imperial College of Science, London, states that as a result of " his seven years most fruitful study of plant injection, Dr. Roach has developed it into a precise technique which can be followed by others and has thus placed in our hands a new instrument of great value in both pure and applied biology". No further commendation is necessary to ensure for the monograph a wide circulation. It is very well documented and illustrated, containing over 175 references to literature and as many as 47 diagrams and two half-tone plates.—A.W.R.J.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED FEBRUARY 28, 1939

Province, &c.	Disease	No. of Cases up to date since Jan. 1, 1939	Fresh Cases	Deaths	Recoveries	Balance ill	No. shot
Western	Foot-and-mouth disease	..	..	..	..	..	..
	Piroplasmosis	..	..	..	..	..	..
	Blackquarter	1	..	1	..	..	..
	Rabies	1	..	..	..	..	1
Colombo Municipality	Foot-and-mouth disease	15	15	2	11	1	1
	Anthrax	..	..	..	..	..	..
	Rabies	..	..	..	..	..	..
	Piroplasmosis	2	2	..	2	..	..
Cattle Quarantine Station	Foot-and-mouth disease	..	..	..	..	..	..
	Anthrax	14	10	14	..	..	..
Central	Foot-and-mouth disease	40	40	..	..	40	..
	Anthrax	1	1	1	..	..	..
	Rabies	4	2	..	..	..	4
	Contagious mange	6	6	..	1	5	..
	Blackquarter	1	1	1	..	..	..
	Piroplasmosis	5	5	1	4	..	..
Southern	Foot-and-mouth disease	..	..	..	..	..	..
	Rabies	..	..	..	..	..	..
Northern	Foot-and-mouth disease	109	40	5	96	8	..
	Rabies	..	..	..	..	..	..
Eastern	Foot-and-mouth disease	2	2	..	..	2	..
North-Western	Foot-and-mouth disease	10	10	..	..	10	..
	Goat Pox	..	..	..	..	..	..
	Haemorrhagic Septicaemia	..	..	..	..	..	..
	Piroplasmosis	..	..	..	..	..	..
	Contagious mange	..	..	..	..	..	..
	Rabies	1	..	..	..	..	1
North-Central	Foot-and-mouth disease	1,276	238	..	1,038	238	..
	Blackquarter	..	..	..	..	..	..
	Haemorrhagic Septicaemia	..	..	..	..	..	..
Uva	Foot-and-mouth disease	..	..	..	..	..	..
	Rabies	..	..	..	..	..	..
	Blackquarter	..	..	..	..	..	..
Sabaragamuwa	Foot-and-mouth disease	..	..	..	..	..	..
	Haemorrhagic Septicaemia	1	..	1	..	..	..

Department of Agriculture,
Peradeniya, March 16, 1939.

T. M. Z. MAHAMOOTH,
for Deputy Director (Animal Husbandry)
and Government Veterinary Surgeon.

METEOROLOGICAL REPORT, FEBRUARY, 1939

STATION	TEMPERATURE				HUMIDITY		Amount of Cloud	RAINFALL		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	DAY	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Ins.		Ins.
Colombo ..	87·5	+0·9	69·4	—2·8	64	90	2·6	0·05	2	— 2·15
Puttalam ..	89·4	+1·4	68·2	—2·0	68	92	3·8	0·73	2	— 0·34
Mannar ..	85·5	—1·2	71·9	—1·9	68	90	3·2	1·24	3	— 0·49
Jaffna ..	84·4	—1·3	70·7	—1·7	66	93	3·2	4·20	1	+ 3·04
Trincomalee ..	81·1	—1·7	74·7	—1·1	76	84	3·8	2·42	5	+ 0·38
Batticaloa ..	81·7	—1·3	72·6	—1·2	77	88	4·5	2·36	7	— 0·32
Hambantota ..	86·2	+0·3	71·6	—1·3	67	85	2·8	0·28	3	— 0·76
Galle ..	84·4	—0·9	72·3	—1·3	74	88	3·4	4·51	7	+ 1·52
Ratnapura ..	92·6	+1·0	68·7	—2·7	60	90	4·0	0·71	6	— 3·73
Anuradhapura ..	86·1	—0·7	64·5	—5·3	66	97	3·7	3·32	4	+ 1·83
Kurunegala ..	91·0	+1·4	65·8	—3·9	56	92	3·6	0·01	1	— 1·68
Kandy ..	87·2	+1·2	64·3	—3·0	54	84	1·8	0·01	1	— 1·79
Badulla ..	78·0	—1·1	60·1	—3·2	70	94	3·7	1·73	6	— 0·76
Diyatalawa ..	75·5	+0·7	54·9	—1·7	69	78	3·8	0·66	6	— 1·14
Hakgala ..	70·4	+0·6	48·8	—2·1	66	76	5·0	1·37	7	— 2·05
Nuwara Eliya ..	69·6	—0·3	40·8	—3·8	58	88	4·8	0·73	7	— 0·98

For the fifth consecutive month, the rainfall was below normal over the greater part of the Island, stations reporting excess being mainly confined to the Northern and North-Central Provinces and the northern half of the Eastern Province. February is a month of small rainfall averages in general, and rainfall deficits, therefore, cannot usually attain high values. Deficits were generally less than 2 inches, except in the mid- and low-country to the west and south of the main hill masses, where most stations were between 2 and 5 inches below normal.

The greatest deficits were 4·75 inches at Marambekande and 4·70 inches at Detanagalla. The greatest excess was 3·04 inches, at Jaffna, while excesses over 2 inches were reported from Mankulam, Nanchchaduwa, Jaffna College, Kirimutti, Mihintale, and Kadukkamunai.

The highest monthly total was 9·70 inches, at Hendon, while 5 other stations, St. Martin's Upper and Lower, Pilacholai, Valaichchanai, and Kirimutti, all reported totals of over 5 inches. Labugama, with 2·19 inches for the month, was 2·28 inches below normal. A majority of the rainfall stations in Ceylon reported totals of less than 2 inches for the month, the principal exceptions being in the districts along the east coast, on and near the north-eastern slopes of the hills, at the extreme south-west corner of the Island, and in the Jaffna Peninsula. An appreciable number of places, mainly in the North-Western Province, reported no rain at all for February.

During the first half of the month, dry settled weather prevailed, with moderate north-westerly gradients and very low night temperatures. The minimum temperature at Nuwara Eliya fell below freezing point on 5 consecutive nights, between the 4th and 9th, and also on the night of 12–13th, the lowest temperature reached being 28·2°–4° below freezing point—on the morning of the 7th. The minimum temperature recorded at Colombo for the 4–5th, 62·6°F, was only a degree above the lowest ever recorded at that station.

Between the 15th and the 23rd an appreciable amount of rain was experienced over the Island, chiefly as a result of irregularly distributed afternoon or evening thunderstorms. The last five days of the month were particularly dry.

Temperatures were on the whole about normal by day, but were appreciably below normal by night. Cloud amounts and humidity were generally in deficit. The barometric pressure was above normal, while winds at the coast were above average strength, the general direction being north-easterly.

H. JAMESON,
Superintendent, Observatory.